# DETAILED PROJECT REPORT

## VOLUME II - MAIN REPORT
## (PART B)

## SEMI HIGH SPEED RAIL CORRIDOR
## THIRUVANANTHAPURAM TO KASARAGOD

KERALA RAIL DEVELOPMENT CORPORATION LTD

# DETAILED PROJECT REPORT

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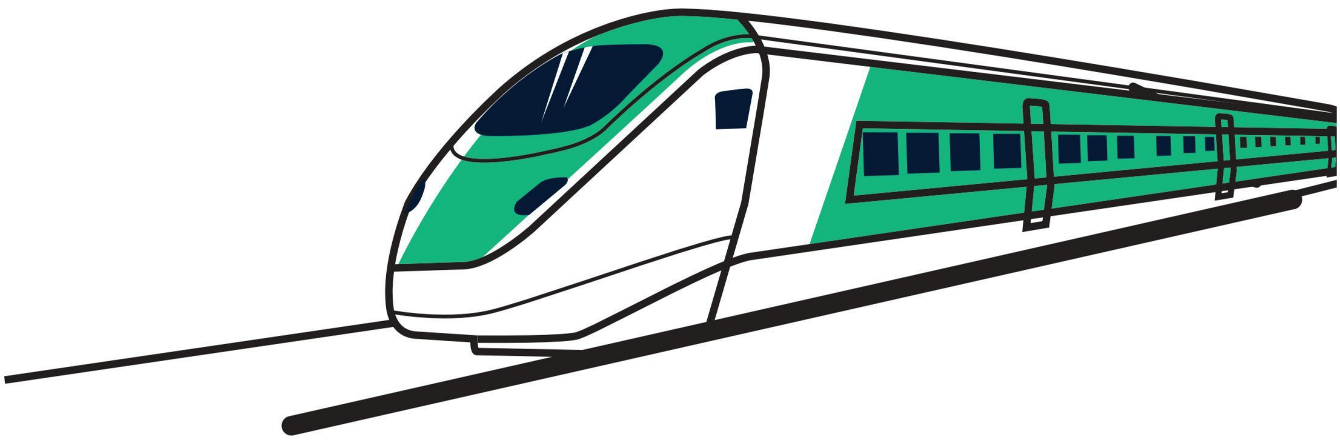
## SEMI HIGH SPEED RAIL CORRIDOR
## THIRUVANANTHAPURAM TO KASARAGOD



K-rail

SYSTRA

# DETAILED PROJECT REPORT – (VOLUME II: PART B)

## DETAILED PROJECT REPORT FOR SILVERLINE (SEMI HIGH SPEED RAIL) FROM THIRUVANANTHAPURAM TO KASARAGOD

| IDENTIFICATION TABLE | |
|---|---|
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| **Project** | SilverLine (Semi High Speed Rail) From Thiruvananthapuram To Kasaragod |
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# TABLE OF CONTENTS

## VOLUME II: PART A

CHAPTER 1: INTRODUCTION

CHAPTER 2: OBJECTIVES OF THE REPORT

CHAPTER 3: REVIEW OF EXISTING DATA & REPORTS

CHAPTER 4: TRAVEL DEMAND FORECAST

CHAPTER 5: BASIC PLANNING PARAMETERS

## VOLUME II: PART B

**6 ALIGNMENT ........ 6-21**

**6.1 GENERAL TOPOGRAPHY OF KERALA STATE AND ALIGNMENT DESIGN ........ 6-21**

6.1.1 Terrains, Landforms and Populations ........ 6-23

**6.2 PRINCIPLES FOR DECIDING THE ALIGNMENT ........ 6-26**

6.2.1 Methodology for the study team to design the alignment ........ 6-26

**6.3 ALTERNATIVES OF ALIGNMENT AND RECOMMENDATION ........ 6-29**

**6.4 GEOMETRIC DESIGN NORMS ADOPTED FOR DESIGN OF SilverLine ........ 6-35**

6.4.1 Norms for horizontal alignment design ........ 6-35

6.4.2 Norms for Vertical alignment design ........ 6-45

**6.5 DESCRIPTION OF RECOMMENDED ALIGNMENT- MID-HIGH LANDS (AS PER ALTERNATIVE-1) ........ 6-47**

6.5.1 The Alignment for SilverLine ........ 6-47

6.5.1.1 Horizontal alignment design ........ 6-47

6.5.1.2 Vertical alignment design ........ 6-47

6.5.2 Route description of recommended alignment :- ........ 6-47

6.5.2.1 Section-1: Thiruvananthapuram- Kollam ........ 6-48

6.5.2.2 Section-2: Kollam- Chengannur ........ 6-51

6.5.2.3 Section-3: Chengannur-Kottayam ........ 6-56

6.5.2.4 Section-4: Kottayam-Ernakulam ........ 6-59

6.5.2.5 Section-5: Ernakulam-Kochi Airport ........ 6-63

6.5.2.6 Section-6: Kochi Airport-Thrissur ........ 6-65

6.5.2.7 Section-7: Thrissur-Tirur ........ 6-67

6.5.2.8 Section-8: Tirur-Kozhikode ........ 6-72

6.5.2.9 Section-9: Kozhikode-Kannur ........ 6-80

6.5.2.10 Section-10: Kannur-Kasaragod :- ........ 6-83

6.5.2.11 Section-11: Kasaragod to Kasaragod Depot. ........ 6-86

6.5.2.12 Yard plans ........ 6-86
6.5.2.13 Details of Route length ........ 6-87

**6.6 IMPORTANT DETAILS OF SILVERLINE PROJECT ........ 6-89**
6.6.1 Lengths of various types of structures ........ 6-89
6.6.2 Religious Structures encountered along the proposed alignment ........ 6-89
6.6.3 Alignment Crossing the existing roads ........ 6-92
6.6.4 Provision for Connectivity with other Systems ........ 6-92

**6.7 OTHER CRITICAL STRETCHES ........ 6-93**

**6.8 GENERAL ALIGNMENT FEATURES OF SilverLine ........ 6-94**
6.8.1 Horizontal Alignment Features ........ 6-94

**6.9 SURVEY TECHNOLOGY ADOPTED FOR ALIGNMENT DESCRIPTION ........ 6-128**
6.9.1 Topographical Surveys by Different Methods:- ........ 6-128
6.9.2 Survey Methodology by LiDAR:- ........ 6-128
6.9.2.1 Survey Teams:- ........ 6-128
6.9.2.2 Project Area ........ 6-129
6.9.2.3 The sequential activities to complete the Topographical survey ........ 6-129
6.9.2.4 Collection of GTS bench marks from Survey of India ........ 6-129
6.9.2.5 Establishment of Control Points :- ........ 6-131
6.9.2.6 Discussion on MCP, SCP and TCPs established at site :- ........ 6-131
6.9.2.7 Typical Details of MCP, SCP And TCPS fixed at site :- ........ 6-131
6.9.3 LIST OF MAIN CONTROL POINTS ........ 6-136
6.9.4 Coordinate System for Project ........ 6-169
6.9.4.1 Coordinate systems ........ 6-169
6.9.4.2 Horizontal Control Network ........ 6-170
6.9.4.2.1 Ground Control Survey Reference ........ 6-170
6.9.4.2.2 DGPS for Horizontal Control :- ........ 6-170
6.9.4.3 Vertical Control Network ........ 6-171
6.9.4.3.1 Vertical Control Network Benchmark ........ 6-171
6.9.4.3.2 Survey Equipment for Vertical Control ........ 6-171
6.9.4.3.3 Densification of Vertical Control in Field ........ 6-171
6.9.4.3.4 Computation Strategy for Level Networks ........ 6-172
6.9.4.3.5 Vertical Height Adjustment Procedure ........ 6-173
6.9.5 Approval of DGCA of LiDAR Aircraft To Fly For Capturing The Data ........ 6-174
6.9.6 Flight Planning ........ 6-174
6.9.7 Ariel Lidar Survey In 600m Width Along The Corridor ........ 6-175
6.9.8 Data Processing to Develop the GAD Plans and other Reports and DTM Data ........ 6-180
6.9.9 AERIAL LiDAR DATA SECURITY ........ 6-180

6.9.10 Site verification and Collection of other Filed Data ........ 6-182
6.9.11 Detailed Topographical Survey Report ........ 6-182

**7 STATION & AREA DEVELOPMENT ........ 7-184**

**7.1 DESIGNING PRINCIPLES OF STATION & AMENITIES: ........ 7-185**

**7.2 STATION TYPES ........ 7-185**

7.2.1 Line Stations ........ 7-185
7.2.2 Terminal Stations ........ 7-186
7.2.3 Transfer Stations ........ 7-186
7.2.4 Inter-Modal Stations ........ 7-186

**7.3 DESIGN OF STATION BUILDING ........ 7-187**

7.3.1 GENERAL DESIGN FEATURES ........ 7-188

**7.4 DESIGN OF PLATFORMS ........ 7-189**

**7.5 STATION FACILITY FOR PASSENGERS ........ 7-190**

7.5.1 Elements of Station Facility ........ 7-190
7.5.2 Means for Efficient Movement of Passengers ........ 7-190
7.5.2.1 Customer satisfaction, Comfort, and Convenience (3 Cs in conceptual design) ........ 7-191

**7.6 OVERALL DESIGN CONCEPT – MODULES IN STAGES ........ 7-191**

**7.7 DESIGN PARAMETERS FOR LARGE STATIONS ........ 7-191**

7.7.1 Layout of Station ........ 7-191
7.7.2 Signages ........ 7-192
7.7.2.1 Types of signage ........ 7-192
7.7.2.1.1 Fixed /Static signage ........ 7-192
7.7.2.1.2 Variable or Dynamic signage ........ 7-192
7.7.2.2 Train Information Display ........ 7-192
7.7.2.3 Station information Centre ........ 7-192
7.7.2.4 Help Point Intercom ........ 7-193
7.7.3 Entry and Exit Points ........ 7-193
7.7.4 Crowding and Control of Peak Hour Traffic ........ 7-193
7.7.5 Parking and Premium Parking Lots ........ 7-193
7.7.6 Passenger Amenities ........ 7-193

**7.8 LEVEL OF SERVICE (LOS) PERFORMANCE STANDARDS REQUIRED ........ 7-194**

7.8.1 Level of Service Standards (LOS) prescribed are as below: ........ 7-194

**7.9 LAYOUT OF STATION & CONCOURSE ........ 7-196**

7.9.1 Station Structure - Typical ........ 7-197
7.9.2 Signal & Communication ........ 7-205

7.9.2.1 For Signals & Communication ........ 7-205
7.9.2.2 For Ticketing System ........ 7-205

**7.10 CONCOURSE DESIGN ........ 7-206**
7.10.1 Hybrid Structures ........ 7-206
7.10.2 Capacity ........ 7-206
7.10.3 Design ........ 7-207
7.10.4 VCEs (Vertical Circulation Elements) ........ 7-208
7.10.4.1 Escalators ........ 7-208
7.10.4.2 Elevators/Lifts ........ 7-210
7.10.4.3 Ramps ........ 7-210
7.10.4.4 Stairs ........ 7-211
7.10.4.5 Travellators ........ 7-211
7.10.4.6 Modular Planning and Interchangeability ........ 7-212

**7.11 STATION SQUARE ........ 7-212**

**7.12 PARKING SPACE ........ 7-213**

**7.13 LOUNGES & WAITING AREA ........ 7-214**
7.13.1 Capacity ........ 7-214
7.13.2 Types of Waiting Areas ........ 7-214
7.13.3 Design Requirement ........ 7-216
7.13.4 Maintenance ........ 7-216

**7.14 PARKING AND VEHICULAR CIRCULATION ........ 7-216**
7.14.1 Capacity Considerations ........ 7-222
7.14.2 Design Considerations: ........ 7-223
7.14.3 Pedestrian Requirements ........ 7-224
7.14.4 Vehicular Circulation: ........ 7-224

**7.15 LIGHTING ........ 7-225**
7.15.1 Introduction ........ 7-225
7.15.2 Increase Natural Light ........ 7-225

**7.16 ACOUSTICS ........ 7-226**
7.16.1 Evacuation of Acoustics ........ 7-226
7.16.2 Reverberation Time (RT) ........ 7-228
7.16.2.1 Acoustic material ........ 7-228

**7.17 EMERGENCY PREPAREDNESS ........ 7-229**

**7.18 STATION ART & ADVERTISINGS ........ 7-230**
7.18.1 Art as integral Component: ........ 7-230

7.18.2 Artist Collaboration ........ 7-230
7.18.3 Advertising ........ 7-231
**7.19 SUSTAINABLE DEVELOPMENT & ENVIRONMENTAL CONSIDERATIONS ........ 7-231**
7.19.1 Goals ........ 7-231
7.19.2 Enforcement ........ 7-232
7.19.2.1 Environmental Impact Assessment ........ 7-232
7.19.2.2 Environmental Management System ........ 7-232
7.19.2.3 Environmental Certification ........ 7-233
**7.20 APPROACH FOR TOD IMPLEMENTATION ........ 7-234**
7.20.1 Station Potential ........ 7-234
7.20.2 TOD in SilverLine stations is classified in three categories ........ 7-234
**7.21 STATION DEVELOPMENT AS GREEN BUILDING ........ 7-235**
7.21.1 What is Green Building ........ 7-235
7.21.1.1 Advantages of Green Building ........ 7-235
7.21.2 Green Building Concept and Architecture Planning ........ 7-235
**7.22 RAKE LOADING FACILITIES AT STATIONS ........ 7-235**
**7.23 Multi-Modal Integration at SilverLine Stations ........ 7-236**
7.23.1 General ........ 7-236
7.23.2 Composition of Multi Modal Integration ........ 7-237
7.23.3 Concept of Multi modal Integration ........ 7-237
7.23.4 Intermodal Interchange Facilities ........ 7-238
7.23.5 Planning Parameters to be considered for multi-modality ........ 7-239
7.23.5.1 Pedestrians ........ 7-239
7.23.5.2 Non-motorised vehicles ........ 7-240
7.23.5.3 Public Transit ........ 7-240
7.23.5.4 Intermediate Public Transit ........ 7-241
7.23.5.5 Pick & Drop (Kiss & Ride) ........ 7-241
7.23.5.6 Park & Ride ........ 7-241
7.23.6 Accessibility to a SilverLine station ........ 7-242
7.23.7 Examples and Case Studies of Multi Modal Integration ........ 7-242
7.23.8 Multimodal integration at SilverLine Stations ........ 7-244
**7.24 CONCLUSION ........ 7-246**
**8 CIVIL ENGINEERING ........ 8-257**
**8.1 GENERAL ........ 8-257**
**8.2 TRACK SUPPORTING STRUCTURES :- ........ 8-257**

8.2.1 Classification: ... 8-257
8.2.1.1 Basic Policy Followed In Design Of Civil Structures: ... 8-257

**8.3 Construction Standards :- ... 8-258**

**8.4 GEOLOGICAL AND GEOTECHNICAL CONDITIONS ALONG THE ALIGNMENT: ... 8-260**
8.4.1 Types of Soils in Kerala: ... 8-260
8.4.2 Soil Quality:- ... 8-262
8.4.3 Methodology adopted for soil investigation:- ... 8-262
8.4.4 Laboratory Investigations:- ... 8-263
8.4.5 General geology and related characteristics:- ... 8-265
8.4.6 Field Investigations:- ... 8-265
8.4.7 Borehole wise brief description of GT investigations:- ... 8-277

**8.5 DESIGN OF STATION LAYOUTS: ... 8-301**
8.5.1 List Of Proposed Stations And Maintenance Facilities:- ... 8-301

**8.6 BASIC STATION LAYOUTS AND DETAILS ... 8-304**
8.6.1 Roll Diagram of the Corridor :- ... 8-304
8.6.2 Station Facilities Planned:- ... 8-306
8.6.3 Detailed Layouts of Stations & Others :- ... 8-310
8.6.3.1 The detailed layouts ... 8-310
8.6.4 Sumamry of Track Length ... 8-326
8.6.5 General principles to determine platform width, length and other details:- ... 8-341
8.6.6 Cross Sections of Station Tracks and Platforms ... 8-341
8.6.7 Classification Of Stations:- ... 8-351

**8.7 TRACK STRUCTURE: ... 8-351**
8.7.1 Rail ... 8-351
8.7.2 Turnouts: ... 8-354
8.7.2.1 Turnouts ... 8-354
8.7.2.2 Technical Specification of Turnouts:- ... 8-354
8.7.2.3 Rails for turnouts:- ... 8-355
8.7.2.4 General technical Specifications of Switches to be used:- ... 8-355
8.7.2.5 Direction of a turnout:- ... 8-356
8.7.2.6 Specifications for Crossings:- ... 8-358
8.7.2.7 Different turnouts used for SilverLine project:- ... 8-358
8.7.2.8 Details of all turnouts proposed for SilverLine:- ... 8-364
8.7.2.9 Specification for the Check Rails ... 8-367

**8.8 TRACK GEOMETRY: ... 8-368**
8.8.1 Gauge:- ... 8-368

8.8.2 Track Centre:- ........ 8-370
8.8.3 Grade Compensation On Curves:- ........ 8-374
8.8.4 Horizontal Curves:- ........ 8-374
8.8.5 Vertical Curve Design:- ........ 8-377
8.8.6 Rail Cant:- ........ 8-378
8.8.7 Ballast Depots:- ........ 8-378
8.8.8 Track Machine Sidings:- ........ 8-378

**8.9 TRACK SUPPORTING STRUCTURE – EMBANKMENT: ........ 8-382**
8.9.1 Embankment Profile:- ........ 8-382
8.9.2 General Terminology for track supporting structures ........ 8-383
8.9.3 Subgrade failure mechanism - To be fought against:- ........ 8-385
8.9.4 Methodology for Study team to select the embankment sections:- ........ 8-385
8.9.5 Blanketing:- ........ 8-386
8.9.6 Subgrade classification:- ........ 8-393
8.9.7 Economical design of embankment by use of Geo-Textiles and Geo-Grid:- ........ 8-395
8.9.7.1 Case Study:- ........ 8-395
8.9.7.2 Geo textiles for Embankment:- ........ 8-396

**8.10 Drainage:- ........ 8-399**
8.10.1 The Provision of Fencing/ Compound Walls:- ........ 8-400
8.10.1.1 Options of Fencing/ Compound walls along SilverLine corridor:- ........ 8-400

**8.11 EMBANKMENT CROSS SECTIONS:- ........ 8-403**
8.11.1 General:- ........ 8-403
8.11.2 Standard Profile:- ........ 8-403
8.11.3 Pressure Below Embankments of various heights:- ........ 8-404
8.11.4 Typical Cross Sections of Embankments:- ........ 8-406

**8.12 CUTTING SECTIONS: ........ 8-419**
8.12.1 General ........ 8-419
8.12.2 Slopes and slope protection Measures:- ........ 8-419
8.12.3 Recommended Cross section of Cut Structures:- ........ 8-427
8.12.4 Additional requirements in cutting stretches:- ........ 8-431

**8.13 GROUND IMPROVEMENT TECHNIQUES METHODS: ........ 8-434**

**8.14 UNDER GROUND STRUCTURES: ........ 8-441**
8.14.1 Cut & Cover:- ........ 8-441
8.14.2 Tunnel:- ........ 8-443
8.14.2.1 General:- ........ 8-443
8.14.2.2 Types of Tunnels:- ........ 8-444

8.14.2.3 Location of the tunnels ..... 8-444
8.14.2.4 Geological Aspects:- ..... 8-445
8.14.2.5 Considerations in Tunnel Design:- ..... 8-446
8.14.2.6 Various shapes of tunnels suitable for Railways ..... 8-446
8.14.2.7 Choice of TBM or NATM:- ..... 8-447
8.14.2.8 Methods for Tunnel Constructions:- ..... 8-447
8.14.2.9 Tunnel shapes and the method of constructions proposed in different projects:- ..... 8-450
8.14.2.10 Recommended cross section of Tunnel ..... 8-451

**8.15 VIADUCT SECTIONS: ..... 8-452**
8.15.1 General:- ..... 8-452
8.15.2 Viaduct section and its design considerations:- ..... 8-453
8.15.3 Optimal spans & optional spans to be provided for Viaducts:- ..... 8-453
*8.15.4* Miscellaneus Features on Viaducts:- ..... 8-458
8.15.5 Discussion on the choice of type of superstructures based on construction: ..... 8-459
8.15.6 List of Viaduct locations:- ..... 8-460

**8.16 BRIDGES: ..... 8-466**
8.16.1 Important Bridges:- ..... 8-467
8.16.2 Foundation Options:- ..... 8-468
8.16.3 Economical span:- ..... 8-469
8.16.4 Standard spans for superstructure:- ..... 8-469
8.16.5 Recommended Cross Sections Of River Bridge Structure:- ..... 8-470
8.16.6 Decision of Superstructure Construction: Pre-cast vs Cast-in-situ ..... 8-472
8.16.7 Load Combinations:- ..... 8-473
8.16.8 List Of Waterways In The Silverline Corridor:- ..... 8-474
8.16.9 RAIL OVER RAIL AND RAIL UNDER RAIL BRIDGES (ROR AND RUR): ..... 8-477

**8.17 ROBs (ROAD OVER BRIDGES) AND ROAD UNDER BRIDGES: ..... 8-480**

**8.18 BALLAST TRANSITION: ..... 8-490**

**8.19 PROTECTION OF STRUCTURES FROM STRAY CURRENT: ..... 8-491**

**8.20 GRADE OF CONCRETE AND STEEL FOR BRIDGES AND OTHER STRUCTURES: ..... 8-492**
8.20.1 Concrete:- ..... 8-492
8.20.2 Reinforcement and Pre-stressed Steel :- ..... 8-493

**8.21 CODES AND REPORTS REFERRED: ..... 8-493**

## VOLUME II: PART C

CHAPTER 9: ROLLING STOCK & DEPOT

CHAPTER 10: POWER SUPPLY ARRANGEMENTS

CHAPTER 11: SIGNALING & TRAIN CONTROL AND COMMUNICATION SYSTEM

CHAPTER 12: TICKETING AND FARE COLLECTION SYSTEM

CHAPTER 13: TRAIN OPERATION, MAINTENANCE PLAN & SAFETY

CHAPTER 14: ENVIRONMENTAL & SOCIAL IMPACT ASSESSSMENT

## VOLUME II: PART D

CHAPTER 15: DETAILED PROJECT COST ESTIMATE

CHAPTER 16: TRANSIT ORIENTED DEVELOPMENT

CHAPTER 17: PROJECT FINANCING OPTIONS

CHAPTER 18: PROJECT IMPLEMENTATION PROGRAM & SCHEDULE

CHAPTER 19: FINANCIAL & ECONOMIC ANALYSIS

CHAPTER 20: SUSTAINABLE TRANSPORT SYSTEM & GREEN INITIATIVES/GREEN BUILDINGS

CHAPTER 21: CONCLUSIONS & RECOMMENDATION

# LIST OF TABLES

TABLE 6-1: SUMMARY OF HORIZONTAL CURVES ON EXISTING RAILWAY LINE ....6-31
TABLE 6-2: COMPARISON OF ALL THREE OPTIONS OF ALTERNATIVE-1 ....6-31
TABLE 6-3: COMPARISON OF ALTERNATIVE-1 AND ALTERNATIVE-2 ....6-33
TABLE 6-4: MINIMUM RADIUS OF ALIGNMENT ....6-35
TABLE 6-5: TRANSITION CURVE LENGTH CALCULATION ....6-39
TABLE 6-6: MINIMUM RADIUS FOR VERTICAL CURVE WITH SHINKANSEN FORMULAE ....6-46
TABLE 6-7: LIST OF CUT AND COVER LOCATIONS ....6-48
TABLE 6-8: LIST OF MAJOR RIVERS CROSSINGS ....6-49
TABLE 6-9: LIST OF TUNNELS LOCATIONS ....6-50
TABLE 6-10: LIST OF VIADUCTS LOCATIONS ....6-50
TABLE 6-11: LIST OF CUT AND COVER LOCATIONS ....6-52
TABLE 6-12: LIST OF MAJOR RIVERS ....6-53
TABLE 6-13: LIST OF TUNNELS LOCATIONS ....6-53
TABLE 6-14: LIST OF VIADUCTS LOCATIONS ....6-53
TABLE 6-15: SHOWING THE LOCATIONS OF CUT AND COVERS ....6-56
TABLE 6-16: SHOWING THE LOCATIONS OF MAJOR RIVERS CROSSINGS ....6-57
TABLE 6-17: SHOWING THE LOCATIONS OF TUNNELS ....6-57
TABLE 6-18: SHOWING THE LOCATIONS OF VIADUCTS ....6-57
TABLE 6-19: SHOWING THE LOCATIONS OF CUT AND COVERS ....6-59
TABLE 6-20: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-61
TABLE 6-21: SHOWING THE LOCATIONS OF TUNNELS ....6-62
TABLE 6-22: SHOWING THE LOCATIONS OF VIADUCTS ....6-62
TABLE 6-23: SHOWING THE LOCATIONS OF CUT AND COVERS ....6-64
TABLE 6-24: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-64
TABLE 6-25: SHOWING THE LOCATIONS OF TUNNELS ....6-64
TABLE 6-26: SHOWING THE LOCATIONS OF VIADUCTS ....6-65
TABLE 6-27: SHOWING THE LOCATIONS OF CUT AND COVER ....6-66
TABLE 6-28: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-66
TABLE 6-29: SHOWING THE LOCATIONS OF TUNNELS ....6-66
TABLE 6-30: SHOWING THE LOCATIONS OF VIADUCTS ....6-66
TABLE 6-31: SHOWING THE LOCATIONS OF CUT AND COVERS ....6-70
TABLE 6-32: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-71
TABLE 6-33: SHOWING THE LOCATION OF TUNNEL ....6-71
TABLE 6-34: SHOWING THE LOCATIONS OF VIADUCTS ....6-71
TABLE 6-35: SHOWING THE LOCATIONS OF CUT AND COVER ....6-79
TABLE 6-36: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-80
TABLE 6-37: SHOWING THE LOCATIONS OF TUNNELS ....6-80
TABLE 6-39: SHOWING THE LOCATIONS OF CUT AND COVERS ....6-81
TABLE 6-40: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-81
TABLE 6-43: SHOWING THE LOCATIONS OF CUT AND COVERS ....6-84
TABLE 6-44: SHOWING THE LOCATIONS OF MAJOR RIVERS ....6-85
TABLE 6-45: SHOWING THE LOCATIONS OF TUNNELS ....6-86
TABLE 6-46: SHOWING THE LOCATIONS OF VIADUCTS ....6-86
TABLE 6-46: SHOWING THE ROUTE LENGTH AND PROPOSED STATION LOCATIONS ....6-87
TABLE 6-47: ABSTRACT OF ALIGNMENT DETAILS ....6-89
TABLE 6-48: DETAILS OF RELIGIOUS STRUCTURES (TEMPLES) ....6-90

TABLE 6-49: DETAILS OF RELIGIOUS STRUCTURES (CHURCHES) ....6-90
TABLE 6-50: DETAILS OF RELIGIOUS STRUCTURES (MASJIDS) ....6-91
TABLE 6-51: HORIZONTAL CURVE DETAILS ....6-95
TABLE 6-52: DETAILS OF VERTICAL ALIGNMENT GEOMETRY AND GRADIENTS ....6-108
TABLE 6-53: LIST OF SOI'S GTS BENCH MARKS ....6-130
TABLE 6-54: DETAILS OF MCP, SCP AND TCPS ....6-131
TABLE 6-55: LIST OF MCP FIXED AT EVERY 25 KM ON GROUND ....6-136
TABLE 6-56: LIST OF TCPS FIXED AT 25 KM ALONG THE ALIGNMENT ON GROUND ....6-145
TABLE 6-57: LIST OF SCPS FIXED AT 25KM ALONG ALIGNMENT ON PILLARS ....6-149
TABLE 6-58: LIST OF ADDITIONAL TCPS AT EVERY 5KM ALONG ALIGNMENT ....6-154
TABLE 6-59: HORIZONTAL AND VERTICAL DATUMS ....6-169
TABLE 6-60: FLIGHT PLANNING TECHNICAL SPECIFICATION ....6-175
TABLE 6-61: AERIAL LIDAR DATA SPECIFICATION ....6-176
TABLE 6-62: AERIAL PHOTOGRAPH SPECIFICATION ....6-179
TABLE 7-1: J.J FRUIN'S QUEUE LOS ....7-194
TABLE 7-2: CIRCULATION FLOWS AS PER J.J FRUIN'S QUEUE LOS ....7-195
TABLE 7-3: ALLOCATED SPACE PER PERSON IN THE TERMINAL AREA ....7-195
TABLE 7-4: CONCEPT FOLLOWED IN SILVERLINE STATIONS ....7-197
TABLE 7-5: TYPE OF SUPPORTING STRUCTURES ....7-198
TABLE 7-6: SILVER LINE STATION ELEMENTS PROPOSED ....7-203
TABLE 7-7: SPACE ALLOCATION FOR SIGNALLING & ALLIED ACTIVITIES ....7-205
TABLE 7-8: THE SPACE REQUIREMENT FOR TICKETING SYSTEM AT STATION. ....7-205
TABLE 7-9: PROPOSED AREAS OF STATION SQUARE ....7-212
TABLE 7-10: ESTIMATED SPACE FOR PARKING ....7-213
TABLE 7-11: SAMPLE CALCULATION FOR CONCOURSE WAITING SPACE ....7-214
TABLE 7-12: PARKING PROVISIONS (FOR PEAK DEMAND) ....7-222
TABLE 7-13: ACCEPTABLE NOISE LEVELS FOR VARIOUS TYPES OF SPACES ....7-226
TABLE 7-14: MAXIMUM SOUND PRESSURE LEVEL (DB) ....7-227
TABLE 7-15: STATION AREA DEVELOPMENT ....7-246
TABLE 8-1: PROPORTION OF TOTAL LENGTH FOR PROPOSED STRUCTURES ....8-258
TABLE 8-2: RIGHT OF WAY FOR DIFFERENT STRUCTURES ....8-259
TABLE 8-3: LABORATARY TESTS CONDUCTED ON SELECTED SAMPLES ....8-263
TABLE 8-4: THE LIST OF RELEVANT LABORATORY TESTS ON SOIL SAMPLES ....8-264
TABLE 8-5: DETAILS OF BOREHOLES ....8-266
TABLE 8-6: LIST OF STATIONS BETWEEN THIRUVANANTHAPURAM AND KASARAGOD ....8-301
TABLE 8-7: DETAILS OF STRUCTURES PLANNED IN STATIONS ....8-306
TABLE 8-8: SUMMARY OF TRACK LENGTH ....8-327
TABLE 8-9: THE SPECIFICATIONS FOR 880 GRADE NON RUNNING LINES ....8-353
TABLE 8-10: SUMMARY OF DIFFERENT TYPES OF TRACK CONNECTIONS ....8-365
TABLE 8-11: GAUGES USED FOR WORLD'S HIGH-SPEED RAILS ....8-369
TABLE 8-12: WORLDWIDE TRACK CENTERS FOR HIGH SPEED RAIL PROJECTS ....8-370
TABLE 8-13: HORIZONTAL CURVE RADIUS AND SPEED LIMIT FOR THE SHINKANSEN ....8-376
TABLE 8-14: THE GRADATION RANGES ....8-388
TABLE 8-15: UIC BASED TWO-LAYER SYSTEM OF BLANKETING ON TRACK FORMATION ....8-390
TABLE 8-16: DESCRIPTION OF SOIL QUALITY CLASS AS PER IS CLASSIFICATION ....8-391
TABLE 8-17: GRADING PERCENTAGE OF BLANKET MATERIAL ....8-392
TABLE 8-18: DETERMINATION OF THE BEARING CAPACITY OF THE SUBGRADE ....8-394
TABLE 8-19: ECONOMY OF USE OF GEO- SYNTHETICS (GEO- TEXTILES AND GEO- GRIDS) ....8-395

TABLE 8-20: GENERAL SPECIFICATIONS OF MULTIFILAMENT WOVEN GEOTEXTILE..........................................8-396
TABLE 8-21: CALCULATION OF DYNAMIC LOAD FROM STATIC LOAD...............................................................8-404
TABLE 8-22: PRESSURE ON SUBSOIL WHEN THE HEIGHT OF FILL BELOW BALLAST VARIES ..............................8-405
TABLE 8-23: OTHER SLOPE PROTECTION MEASURES ..........................................................................................8-420
TABLE 8-24: DESIGN CRITERIA FOR CATCH DITCHES .........................................................................................8-431
TABLE 8-25: CATEGORIES OF GEOSYNTHETICS.....................................................................................................8-441
TABLE 8-26: LIST OF THE LOCATIONS WHERE TUNNELS ARE PROPOSED...........................................................8-445
TABLE 8-27: COMPARISON OF TUNNELS ADOPTED IN VARIOUS RAILWAYS .....................................................8-450
TABLE 8-28: LIST OF LOCATIONS WHERE VIADUCTS ARE PROPOSED ................................................................8-460
TABLE 8-29: LIST OF RIVER BRIDGES AND LOCATIONS ALONG THE ALIGNMENT...............................................8-474
TABLE 8-30: LIST OF ROR AND RUR LOCATIONS ALONG THE ALIGNMENT ........................................................8-477
TABLE 8-31: LIST OF LOCATIONS WHERE ROADS (ROBS/RUBS) CROSSING THE ALIGNMENT & PROPOSED STRUCTURES ..........................................................................................................................................8-482
TABLE 8-32: TYPICAL CONCRETE MIX DESIGN......................................................................................................8-492
TABLE 8-33: GRADE M-60 CONCRETE COMPRESSIVE STRENGTH RESULTS (TYPICAL).......................................8-493
TABLE 8-34: CONCRETE DURABILITY RESULTS .....................................................................................................8-493

# LIST OF FIGURES

FIGURE 6-1: GEOGRAPHY OF KERALA ....................6-22
FIGURE 6-2: THE TOPOGRAPHIC DIVISIONS OF THE STATE OF KERALA ....................6-23
FIGURE 6-3: THE UNIQUE LANDFORM OF THE MID-HIGHLAND REGION OF KERALA....................6-24
FIGURE 6-4: AERIAL VIEW OF THE MID-HIGHLANDS NEAR KAYAMKULAM ....................6-24
FIGURE 6-5: AERIAL IMAGE IN THE NORTH OF THIRUVANANTHAPURAM ....................6-25
FIGURE 6-6: TWO ALTERNATIVES FOR SILVERLINE ALIGNMENT ....................6-30
FIGURE 6-7: SHOWING TWO OPTIONAL ALIGNMENTS FOR KUNDARA DIVERSION....................6-55
FIGURE 6-8: SHOWING TWO OPTIONAL ALIGNMENTS FOR CHENGANNUR DIVERSION....................6-56
FIGURE 6-9: SHOWING TWO OPTIONAL ALIGNMENTS TOWARDS KOTTAYAM....................6-59
FIGURE 6-10: CUT AND CONNECTION LOCATION AT CH: 260400....................6-68
FIGURE 6-11: CUT AND CONNECTION LOCATION AT CH:262150....................6-69
FIGURE 6-12: TYPICAL CROSS SECTION SHOWING EXISTING TRACKS, SILVERLINE TRACKS AND THE ....................6-69
FIGURE 6-13: KOZHIKODE CITY WITH ITS CONGESTED STREETS....................6-73
FIGURE 6-14: ROB CHAINAGE 355+500....................6-74
FIGURE 6-15: KALLAYI RIVER AT CHAINAGE 356+500 ....................6-75
FIGURE 6-16: RUB CHAINAGE 357+200....................6-75
FIGURE 6-17: ROB CHAINAGE 358+000....................6-76
FIGURE 6-18: ROB CHAINAGE 358+950....................6-76
FIGURE 6-19: EXISTING LC’S CHAINAGE 359+300....................6-77
FIGURE 6-20: ROB CHAINAGE 359+800....................6-77
FIGURE 6-21: EXISTING LC’S CHAINAGE 360+250....................6-78
FIGURE 6-22: KOZHIKODE RAILWAY STATION AND PARKING AREA....................6-78
FIGURE 6-24: TYPICAL FIGURE SHOWING MCP LOCATION....................6-132
FIGURE 6-25: TYPICAL FIGURE SHOWING SCP LOCATION ....................6-133
FIGURE 6-26: TYPICAL FIGURE SHOWING TCP LOCATION ....................6-134
FIGURE 6-27: TYPICAL FIGURE SHOWING TCP LOCATION ....................6-135
FIGURE 6-27: DIGITAL LEVELLING WORK IN THE FIELD ....................6-172
FIGURE 6-28: LEVELLING STAFF BEING OBSERVED DURING LEVELLING OPERATION ....................6-172
FIGURE 6-29: EARTH SURFACE, GEOID, AND ELLIPSOID ALONG WITH ORTHOMETRIC HEIGHT....................6-174
FIGURE 7-1: IMAGE OF STATION BUILDINGS ....................7-185
FIGURE 7-2: FAÇADE IMAGE OF THE SILVER LINE STATION....................7-187
FIGURE 7-3: IMAGE OF A WINDSCREEN....................7-188
FIGURE 7-4: SCHEMATIC DIAGRAM SHOWING PASSENGER CIRCULATION FLOW WITHIN THE STATION ....................7-189
FIGURE 7-5: IMAGE OF TICKET COUNTERS....................7-190
FIGURE 7-6: IMAGE OF PAID CONCOURSE ....................7-194
FIGURE 7-7: INDICATIVE IMAGE OF COMMERCIAL ZONE IN THE FREE CONCOURSE AREA....................7-196
FIGURE 7-8: TYPICAL STATION STRUCTURE ....................7-197
FIGURE 7-9: KOLLAM STATION ....................7-201
FIGURE 7-10: WAYSIDE STATIONS ....................7-201
FIGURE 7-11: KOZHIKODE STATION ....................7-202
FIGURE 7-12: TERMINAL STATIONS ....................7-202
FIGURE 7-13: IMAGE OF WAITING ROOM FOR SECOND CLASS PASSENGERS....................7-214
FIGURE 7-14: IMAGE OF LAVATORIES FOR SILVER LINE ....................7-215
FIGURE 7-15: THIRUVANANTHAPURAM SILVERLINE STATION LAYOUT PLAN ....................7-216
FIGURE 7-16: KOLLAM SILVERLINE STATION LAYOUT PLAN ....................7-217
FIGURE 7-17: CHENGANNUR SILVERLINE STATION LAYOUT PLAN ....................7-217

FIGURE 7-18: KOTTAYAM SILVERLINE STATION LAYOUT PLAN ....7-218
FIGURE 7-19: ERNAKULAM SILVERLINE STATION LAYOUT PLAN....7-218
FIGURE 7-20: KOCHI AIRPORT SILVERLINE STATION LAYOUT PLAN ....7-219
FIGURE 7-21: THRISSUR SILVERLINE STATION LAYOUT PLAN....7-219
FIGURE 7-22: TIRUR SILVERLINE STATION LAYOUT PLAN....7-220
FIGURE 7-23: KOZHIKODE SILVERLINE STATION LAYOUT PLAN....7-220
FIGURE 7-24: KANNUR SILVERLINE STATION LAYOUT PLAN ....7-221
FIGURE 7-25: KASARAGOD SILVERLINE STATION LAYOUT PLAN ....7-221
FIGURE 7-26: ILLUSTRATION OF NEW MODERN INDIAN STYLE ARCHITECTURE ....7-226
FIGURE 7-27: NR - NOISE RATING DIAGRAM....7-228
FIGURE 7-28: SECURITY AND EMERGENCY PREPAREDNESS PLANNING GUIDE ....7-230
FIGURE 7-29: PROPOSED SIDE & END LOADING PLATFORMS FOR FULL RAKE RO-RO TRAIN ....7-236
FIGURE 7-30: HIERARCHY OF MODES BASED ON SPACE EFFICIENCY....7-238
FIGURE 7-31: ELEMENTS OF PEDESTRIAN ACCESS TO PUBLIC TRANSPORT ....7-240
FIGURE 7-32: KEY PLAN SHOWING LOCATION OF PROPOSED THIRUVANANTHAPURAM STATION....7-247
FIGURE 7-33: KEY PLAN SHOWING LOCATION OF PROPOSED THIRUVANANTHAPURAM RORO ....7-247
FIGURE 7-34: KEY PLAN SHOWING LOCATION OF PROPOSED KOLLAM STATION....7-248
FIGURE 7-35: KEY PLAN SHOWING LOCATION OF PROPOSED KOLLAM DEPOT....7-248
FIGURE 7-36: KEY PLAN SHOWING LOCATION OF PROPOSED CHENGANNUR STATION ....7-249
FIGURE 7-37: KEY PLAN SHOWING LOCATION OF PROPOSED KOTTAYAM STATION....7-249
FIGURE 7-38: KEY PLAN SHOWING LOCATION OF PROPOSED ERNAKULAM STATION....7-250
FIGURE 7-39: KEY PLAN SHOWING LOCATION OF PROPOSED ERNAKULAM RORO ....7-250
FIGURE 7-40: KEY PLAN SHOWING LOCATION OF PROPOSED COCHIN AIRPORT STATION....7-251
FIGURE 7-41: KEY PLAN SHOWING LOCATION OF PROPOSED THRISSUR RORO ....7-251
FIGURE 7-42: KEY PLAN SHOWING LOCATION OF PROPOSED THRISSUR STATION ....7-252
FIGURE 7-43: KEY PLAN SHOWING LOCATION OF PROPOSED TIRUR STATION ....7-252
FIGURE 7-44: KEY PLAN SHOWING LOCATION OF PROPOSED KOZHIKODE STATION ....7-253
FIGURE 7-45: KEY PLAN SHOWING LOCATION OF PROPOSED KOZHIKODE RORO ....7-253
FIGURE 7-46: KEY PLAN SHOWING LOCATION OF PROPOSED KANNUR STATION ....7-254
FIGURE 7-47: KEY PLAN SHOWING LOCATION OF PROPOSED KANNUR RORO....7-254
FIGURE 7-48: KEY PLAN SHOWING LOCATION OF PROPOSED KASARAGOD....7-255
FIGURE 7-49: KEY PLAN SHOWING LOCATION OF PROPOSED KASARAGOD DEPOT ....7-255
FIGURE 8-1: TYPES OF SOILS IN KERALA....8-261
FIGURE 8-2: ROLL DIAGRAM OF SILVERLINE PROJECT BETWEEN THIRUVANANTHAPURAM TO THRISSUR. ....8-304
FIGURE 8-3: ROLL DIAGRAM OF SILVERLINE PROJECT BETWEEN THRISSUR TO KASARAGOD ....8-305
FIGURE 8-4: THIRUVANANTHAPURAM STATION (ON VIADUCT) ....8-310
FIGURE 8-5: THIRUVANANTHAPURAM RORO STATION (AT-GRADE) ....8-311
FIGURE 8-6: KOLLAM STATION (AT-GRADE) ....8-312
FIGURE 8-7: KOLLAM DEPOT (AT-GRADE)....8-313
FIGURE 8-8: CHENGANNUR STATION (AT-GRADE) ....8-314
FIGURE 8-9: KOTTAYAM STATION (AT-GRADE)....8-315
FIGURE 8-10: ERNAKULAM STATION (ON VIADUCT)....8-316
FIGURE 8-11: ERNAKULAM RORO STATION (AT-GRADE) ....8-317
FIGURE 8-12: KOCHI AIRPORT STATION (AT-GRADE) ....8-317
FIGURE 8-13: THRISSUR RORO STATION (AT-GRADE) ....8-318
FIGURE 8-14: THRISSUR STATION (ON VIADUCT)....8-319
FIGURE 8-15: TIRUR STATION (AT-GRADE) ....8-320
FIGURE 8-16: KOZHIKODE STATION (UNDERGROUND)....8-321

FIGURE 8-17: KOZHIKODE RORO STATION (AT-GRADE) ....8-322
FIGURE 8-18: KANNUR STATION (AT-GRADE) ....8-323
FIGURE 8-19: KANNUR RORO STATION (AT-GRADE)....8-324
FIGURE 8-20: KASARAGOD STATION (AT-GRADE)....8-325
FIGURE 8-21: KASARAGOD DEPOT & RORO STATION (AT-GRADE) ....8-326
FIGURE 8-22: THIRUVANANTHAPURAM STATION (ON VIADUCT)....8-342
FIGURE 8-23: THIRUVANANTHAPURAM RORO STATION (AT-GRADE) ....8-342
FIGURE 8-24: KOLLAM STATION (AT-GRADE)....8-343
FIGURE 8-25: CHENGANNUR STATION (AT-GRADE) ....8-343
FIGURE 8-26: KOTTAYAM STATION (AT-GRADE)....8-344
FIGURE 8-27: ERNAKULAM STATION (ON VIADUCT)....8-344
FIGURE 8-28: ERNAKULAM RORO STATION (AT-GRADE) ....8-345
FIGURE 8-29: KOCHI AIRPORT STATION (AT-GRADE) ....8-345
FIGURE 8-30: THRISSUR RORO STATION (AT-GRADE) ....8-346
FIGURE 8-31: THRISSUR STATION (ON VIADUCT)....8-346
FIGURE 8-32: TIRUR STATION (AT-GRADE) ....8-347
FIGURE 8-33: TIRUR RORO STATION (AT-GRADE) ....8-347
FIGURE 8-34: KOZHIKODE STATION (UNDERGOUND) ....8-348
FIGURE 8-35: KOZHIKODE RORO STATION (AT-GRADE) ....8-348
FIGURE 8-36: KANNUR STATION (AT-GRADE) ....8-349
FIGURE 8-37: KANNUR RORO STATION (AT-GRADE)....8-349
FIGURE 8-38: KASARAGOD STATION (AT-GRADE)....8-350
FIGURE 8-39: KASARAGOD RORO STATION (AT-GRADE) ....8-350
FIGURE 8-40: CROSS SECTION OF 60 KG RAIL....8-353
FIGURE 8-41: CONSTITUENTS OF A TURNOUT ....8-355
FIGURE 8-42: CONSTITUENTS OF A SWITCH....8-357
FIGURE 8-43: CONSTITUENTS OF A CROSSING ....8-357
FIGURE 8-44: CONSTITUENTS OF A LEFT HAND TURNOUT ....8-359
FIGURE 8-45: DIMENSIONS OF A 1 IN 18 TURNOUT....8-359
FIGURE 8-46: PICTURE OF SHINKANSEN TYPE 1 IN 18 TURNOUT WITH MOVABLE CROSSING ....8-360
FIGURE 8-47: SHOWING RH CROSSOVER BETWEEN TWO PARALLEL TRACKS....8-360
FIGURE 8-48: 1 IN 9 (300) LH AND RH TURNOUTS....8-361
FIGURE 8-49: DESIGN PARAMETERS OF 1 IN 9 TURNOUT ....8-362
FIGURE 8-50: SYMMETRICAL SPLIT ....8-362
FIGURE 8-51: RH CROSSOVER BETWEEN TWO PARALLEL TRACKS....8-363
FIGURE 8-52: 1 IN 9 SCISSORS CROSS OVER....8-364
FIGURE 8-53: SKETCH SHOWING THE CHECK RAIL AND ITS PHYSICAL PROPERTIES. ....8-368
FIGURE 8-54: STANDARD GAUGE TRACK ....8-369
FIGURE 8-55: EXTRA CLEARANCES FOR MAINLINES ....8-371
FIGURE 8-56: EXTRA CLEARANCES FOR DEPOT LINES....8-372
FIGURE 8-57: STANDARD FEATURES OF A TYPICAL CURVE. ....8-375
FIGURE 8-58: SUMMITS AND SAGS IN VERTICAL ANGLES IN DIFFERENT PLANES ....8-377
FIGURE 8-59: A SKETCH SHOWING THE MACHINE SIDING PROPOSED AT KOLLAM DEPOT ....8-379
FIGURE 8-60: A SKETCH SHOWING THE MACHINE SIDING PROPOSED AT THRISSUR RORO ....8-380
FIGURE 8-61: A SKETCH SHOWING THE MACHINE SIDING PROPOSED AT KANNUR ....8-380
FIGURE 8-62: COMPONENTS OF EMBANKMENT....8-382
FIGURE 8-63: SCHEMATIC CROSS SECTION OF EMBANKMENT FOR TWO TRACKS....8-383
FIGURE 8-64: PARTICL SIZE DISTRIBUTION CURVES ....8-388

FIGURE 8-65: ENVELOPING CURVES FOR BLANKET MATERIAL (REF: REPORT NO. RDSO/2007/GE :0014): .......8-393
FIGURE 8-66: APPLICATION OF GEO-TEXTILES AND GEO-GRIDS IN THE FORMATION .......................................8-395
FIGURE 8-67: VIEWS OF WOVEN GEOTEXTILE AVAILABLE IN THE MARKET.......................................................8-397
FIGURE 8-68: METHOD OF LAYING GEO- TEXTILE ON THE PREPARED SURFACE...............................................8-398
FIGURE 8-69: LAYING OF BIAXIAL GEOGRIDS.......................................................................................................8-399
FIGURE 8-70: SOLAR PANELS ON PRECAST RCC COMPOUND WALLS ..................................................................8-401
FIGURE 8-71: SHOWING THE TENTATIVE CROSS SECTION OF THE FENCING .....................................................8-402
FIGURE 8-72: SHOWING THE TENTATIVE CROSS SECTION OF THE FENCING .....................................................8-402
FIGURE 8-73: TYPICAL EMBANKMENT CROSS SECTION ......................................................................................8-403
FIGURE 8-74: TYPICAL ARRANGEMENT OF SIGNAL AND POWER DUCT ON EMBANKMENT .............................8-404
FIGURE 8-75: EMBANKMENT 2 M HIGH ON STRONG GROUND ..........................................................................8-406
FIGURE 8-76: EMBANKMENT 2M HIGH ON WEAK GROUND..............................................................................8-407
FIGURE 8-77: EMBANKMENT 2 M HIGH ON VERY WEAK GROUND ....................................................................8-408
FIGURE 8-78: ARRANGEMENT OF EMBANKMENT OF ZERO HEIGHT WITH UNDER REAMED PILES ...................8-409
FIGURE 8-79: EMBANKMENT WITH 2.5 M CLEAR BOX ON STRONG GROUND..................................................8-410
FIGURE 8-80: EMBANKMENT WITH 2.5 M CLEAR BOX ON WEAK GROUND ......................................................8-411
FIGURE 8-81: EMBANKMENT WITH 2.5 M CLEAR BOX, ON VERY WEAK GROUND ............................................8-411
FIGURE 8-82: EMBANKMENT WITH 3.6M CLEAR BOX ON STRONG GROUND ...................................................8-412
FIGURE 8-83: EMBANKMENT WITH 3.6 CLEAR BOX ON WEAK............................................................................8-413
FIGURE 8-84: EMBANKMENT WITH 3.6 M CLEAR BOX ON VERY WEAK GROUND ............................................8-413
FIGURE 8-85: EMBANKMENT 2M-8M HIGH WHERE LAND COST HIGH ..............................................................8-414
FIGURE 8-86: TYPICAL CROSS SECTION OF GEOSYNTHETIC-REINFORCED EMBANKMENT ................................8-415
FIGURE 8-87: TYPICAL CROSS SECTION WHERE THE LAND COST IS NOT HIGH .................................................8-417
FIGURE 8-88: MEASURES WITH RCC SHEET PILES AGAINST SOIL PIPING ...........................................................8-418
FIGURE 8-89: BANDED DRY MASONRY WALL .......................................................................................................8-423
FIGURE 8-90: GABION WALL...................................................................................................................................8-424
FIGURE 8-91: GABION WALL WITH GEO GRID REINFORCEMENT .......................................................................8-425
FIGURE 8-92: SOIL NAILING OF A FAILURE PRONE SLOPE ..................................................................................8-426
FIGURE 8-93: ARRANGEMENT OF CUT STRUCTURE WHERE FORMATION SOIL IS MET WITH SOIL INCLUDING BLACK COTTON HAVING SBC<5 T/M$^2$..........................................................................................8-427
FIGURE 8-94: TYPICAL ARRANGEMENT OF CUT STRUCTURE WITH RCC RETAINING WALL (3M-6M) ................8-428
FIGURE 8-95: TYPICAL ARRANGEMENT WITH RCC R/WALL AND GABION WALL AT TOP 3M (6-9M) ................8-429
FIGURE 8-96: TYPICAL ARRANGEMENT WITHOUT RCC RETAINING WALL (0-6M) ............................................8-429
FIGURE 8-97: TYPICAL ARRANGEMENT WITHOUT RCC RETAINING WALL (0-9M) ............................................8-430
FIGURE 8-98: GABION WALL WITH GEOGRID REINFORCEMENT ........................................................................8-431
FIGURE 8-99: TYPICAL CUT SECTION WITH SIDE AND CATCH WATER DRAIN ...................................................8-433
FIGURE 8-100: SCHEMATIC SKETCH OF A LOAD TRANSFER PLATFORM.............................................................8-440
FIGURE 8-101: CUT & COVER STRUCTURE BEFORE AND AFTER CUTTING..........................................................8-442
FIGURE 8-102: CUT & COVER STRUCTURE BEFORE AND AFTER TUNNEL ..........................................................8-443
FIGURE 8-103: DIFFERENT TUNNEL BORING METHODS .......................................................................................8-450
FIGURE 8-104: TYPICAL CROSS SECTION OF TUNNEL/ CUT & COVER BEFORE AND AFTER TUNNEL..................8-452
FIGURE 8-105: GRAPH SHOWING THE LAND VALUE /M$^2$, COST VIADUCT/ EMBANKMENT .............................8-453
FIGURE 8-106: GENERAL ARRANGEMENT OF VIADUCT WITH 4 - I GIRDERS, 2 – COLUMNS / PIERS, 6 PILES OF 1.0M DIAMETER FOR LESS CAPACITY PILES ..........................................................................................8-454
FIGURE 8-107: GENERAL ARRANGEMENT OF VIADUCT WITH I GIRDER AND 4 NOS OF PILES -1.2M DIA. .........8-455
FIGURE 8-108: GENERAL ARRANGEMENT OF VIADUCT WITH 4 - I GIRDERS, 2 COLUMNS / PIERS AND OPEN RAFT FOUNDATION FOR HIGH SBC AT TOP LEVELS ............................................................................8-456

FIGURE 8-109: GENERAL ARRANGEMENT OF VIADUCT WITH 4-I GIRDERS, SINGLE COLUMN PIER AND OPEN FOUNDATION FOR PERMITTING ROADS ........................................ 8-457
FIGURE 8-110: GENERAL ARRANGEMENT OF VIADUCT WITH TWIN-U TYPE GIRDER, 2 COLUMNS AND OPEN FOUNDATIONS FOR MORE VERTICAL CLEARANCE ........................................ 8-458
FIGURE 8-111: GENERAL ARRANGEMENT OF VIADUCT WHERE OHE MAST IS ON GIRDER ........................................ 8-459
FIGURE 8-112: TYPICAL BOX CULVERT FOR A SPAN OF 8M ........................................ 8-470
FIGURE 8-113: GENERAL ARRANGEMENT OF RIVER BRIDGE WITH 4 - I GIRDERS, 2 – COLUMNS AND 6 PILES OF 1.2M DIAMETER ........................................ 8-471
FIGURE 8-114: GENERAL ARRANGEMENT OF RIVER BRIDGE WITH TWIN U - TYPE GIRDER, 2 – COLUMNS AND 6 - PILES OF 1.2M DIAMETER ........................................ 8-472
FIGURE 8-115: GENERAL ARRANGEMENT OF ROR WITH STEEL - RCC COMPOSITE GIRDER ........................................ 8-479
FIGURE 8-116: ENLARGED CROSS SECTION OF COMPOSITE GIRDER ........................................ 8-480
FIGURE 8-117: TYPICAL CROSS SECTION OF ROB ........................................ 8-481
FIGURE 8-118: DETAILS OF BALLAST TRANSITION FROM BALLAST LESS TRACK TO BALLASTED TRACK (TUNNEL TO CUTTING) ........................................ 8-491

# DETAILED PROJECT REPORT

## SEMI HIGH SPEED RAIL CORRIDOR
## THIRUVANANTHAPURAM TO KASARAGOD

## VOLUME II - MAIN REPORT
## (PART B)

## CHAPTER 6
## ALIGNMENT

# 6 ALIGNMENT

This chapter deals with the alignment design and details for the Thiruvananthapuram-Kasaragod SilverLine project duly describing the strategy, preferences, methodology and procedures followed, surveys carried out and details collected, interpretation and analysis done and the final results of route, alignment, stations, curves, bridges, tunnels, viaducts and other features of the alignment selected for the project as discussed hereunder.

## 6.1 GENERAL TOPOGRAPHY OF KERALA STATE AND ALIGNMENT DESIGN

Kerala is a narrow stretch of land sandwiched between the Western Ghats in the east and Arabian Sea in the west. Kerala has a width from 30 to 120 kms with an average of about 67 km. The land is traversed by 44 rivers of which 41 have their course towards the Arabian Sea the other 3 rivers are east flowing. They take their origin from the Western-Ghats and flow west until they drain into either the backwaters or flow into the Arabian Sea. The total annual rainfall of the State varies from about 4500 mm in the northern Kerala to about 2000 mm in the south. Ernakulam and Thrissur Districts receive rainfall 3210 mm and 3160 mm respectively which are above the State average. The rivers are mainly monsoon fed and most of them are perennial in character.

Kerala has unique landforms, the coastal plains and the mid-highlands, which lie between the Western Ghats mountain range in the east and the Arabian Sea in the west. That is why finding a suitable alignment for building a stable and safe high-speed line running almost in the full length of the State from Thiruvananthapuram to Kasaragod is a very challenging task. Building this line would require marshalling of engineering skills and innovations to give a safe and stable line at optimal cost. Despite the costs and the challenges, the fact remains that the State needs a rail-based means of fast travel for its socio-economic growth which has been constrained for the past many years by the slow speed of surface transport.

The undulating landforms prevailing all over the State cover about 70% of the State’s land area and have resulted in slow speed of surface transport. The highways basically find high ground by connecting patches of high ground in a sequence. The result is that the roads are highly curved with steep gradients as the roads move up and down around small hillocks between the alternating low and high grounds.

The existing IR’s railway lines have been laid in a slightly different manner; basically, closer to the low ground as they traverse the region on cuttings in the slopes of the hillocks and mounds and on high embankments in low lying flats.

Both the railway lines and roads are badly affected in the rainy season because of waterlogging and slippages in hill slopes which occur regularly in the region. Speed is relatively better in portions where the railway line and roads are situated in the flat terrain.

These landforms and the dispersed population present a serious challenge to building a high-speed railway line. Additionally, in the coastal plains, the main problem is of low bearing capacity which is encountered almost everywhere. The soils of the coastal plains

are likely to be very deep with a sandy texture. Rock, and stiff soils are usually encountered at more than 30 to 50 m depth. The sand content of the soil near the surface, goes up to 80% and clay up to 15%. Even though these soils have a high water table, the water holding capacity is likely to be poor due to the predominance of the sandy strata. In the backwaters, the content of silt and clay is relatively higher. In the paddy field of Kuttanad, sandy clay loam to clay is the predominant soil. On the other hand, in the midland's undulating terrain with waterlogged regions surrounding the hillocks and mounds, the main suspect is of the instability of cuttings in laterite soil/rock which is the dominant material on the surface up to several meter depth. Further, high embankments would need accurate design after due analysis before actual execution in the lowlands which are prone to waterlogging and flooding to prevent large settlement problems of ground. Preferably, the semi high-speed line would have to be carried over the lowlands between the hillocks on high viaducts. Alternatively, the line would have to be carried in tunnels laid at shallow depth below the ground by avoiding both the hillocks and the lowlands. (See **Figure 6.1)**

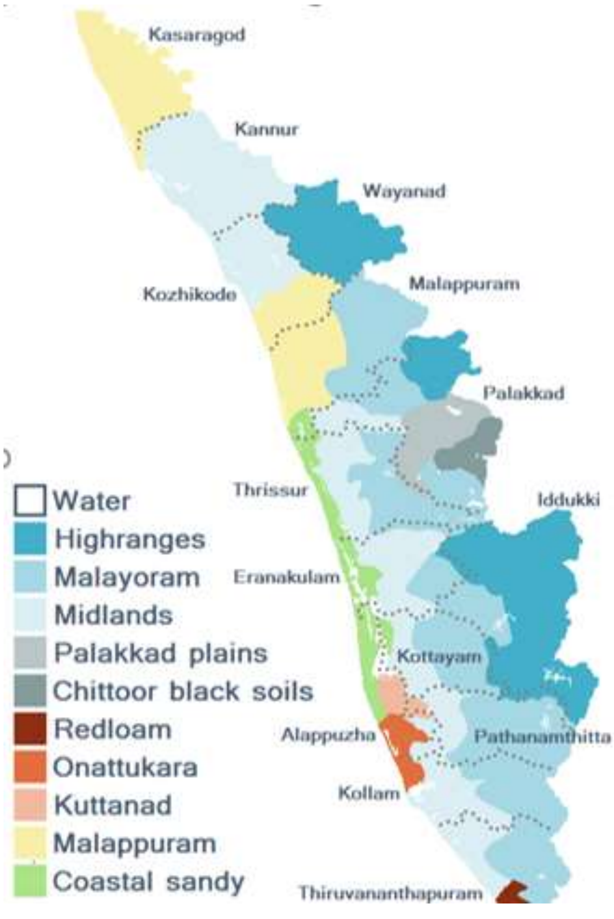



**Figure 6-1: Geography of Kerala**

In view of the tedious Topography and Geology of the State, it becomes more important to decide the alignment with due diligence taking care of all the important and crucial aspects prevalent in the State for making the alignment safe, economical, durable and with minimal dislocation to the public.

### 6.1.1 Terrains, Landforms and Populations

Apart from the coastal plains and the mid-highlands, which lie between the Western Ghats mountain range in the east and the Arabian Sea in the west, the coastline, which is full of endless sandy beaches, is remarkably straight with mild curves. Based on the topography, the entire region can be divided into three zones from west to east (See the schematic diagram in **Figure 6.2**).

**Zone 1**

The coastal plains and the backwaters are an area of estuaries, lagoons, alluvial plains and beach ridges and dunes fringing the coast. It covers about 20% of the area of the State with elevation ranging between 0 m and 15m. It has a maximum width of about 25 Km near Alappuzha. The coastal plains are full of backwaters, which are a chain of brackish lagoons and shallow lakes lying parallel to the Arabian Sea coast. The network of the backwaters includes five large lakes linked by canals, both manmade and natural, fed by 41 rivers, and extending more than half the length of Kerala State. The backwaters have been formed by the action of waves and shore currents creating low barrier islands across the mouths of the many rivers flowing down from the Western Ghats range. Vembanad lagoon is the largest waterbody extending about 183 km parallel to the coast from north of Varkala to Azhikode in the north of Kochi with six major rivers flowing into it. Kuttanad, south of the Vembanad lagoon is a deltaic formation of mainly four rivers Achankovil, Pampa, Manimala, and Meenachil. The second largest lagoon is the Asthamudy near Kollam, which has a length of 16 km and width of 15 km.

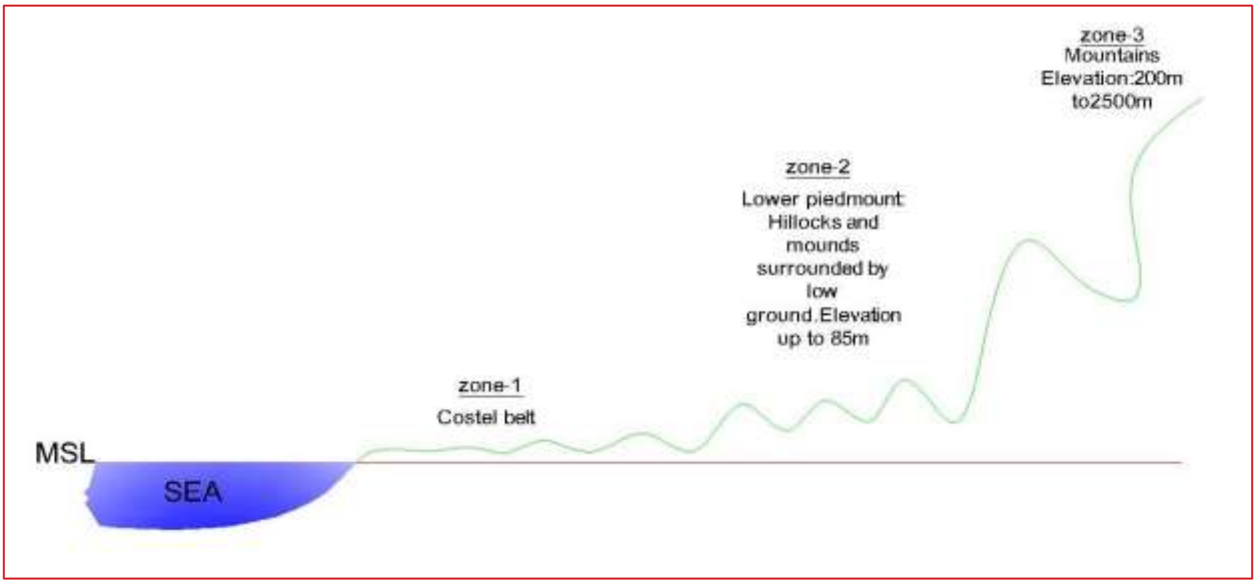



**Figure 6-2: The topographic divisions of the State of Kerala**

**Zone 2**

The lower piedmont, also referred as mid-highlands, consists of the intensely dissected west-east sloping surface of the earth with hillocks and mounds surrounded by wide watercourses and lowlands which have been formed by the swiftly flowing rivers and

streams. This region occupies nearly 50% of the State's total area. The region's unique landform of alternating sequences of hillocks and mounds surrounded by low grounds with elevation difference ranging from 20 m to 85 m between the high and low grounds has been formed by rivers, which have been changing their course over the millennia as they dissected the earth, leaving behind the low lands around the present-day hillocks and mounds. In the rainy season, when the low-lying areas around the hillocks and mounds are waterlogged, the region looks like a sea with a dense cluster of islands when seen from above (See the **Figure 6.3** & Google Earth image of the region near Kayamkulam, north of the Ashtamudi Lake in **Figure 6.4**).

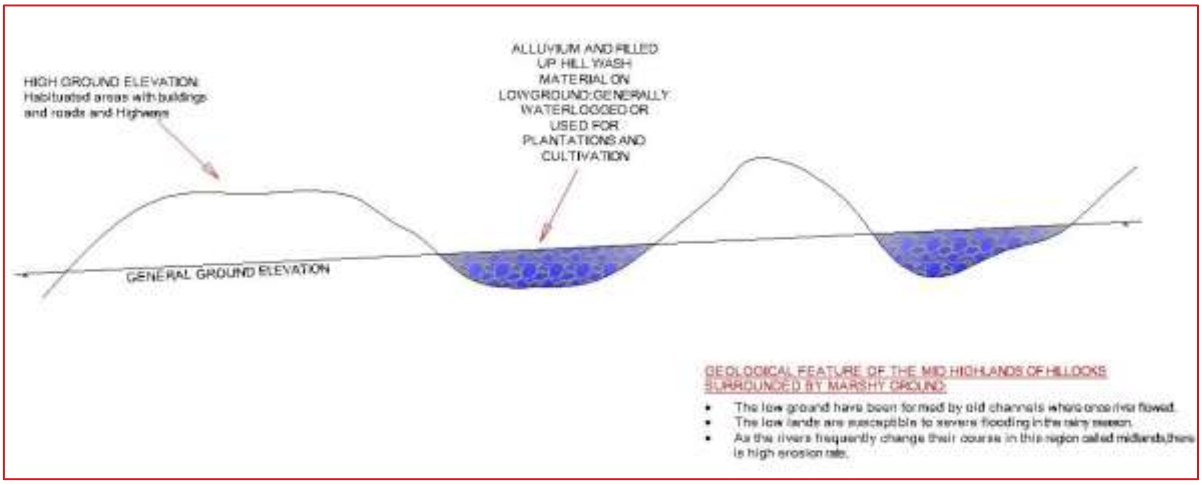



**Figure 6-3: The unique landform of the mid-highland region of Kerala**


**Figure 6-4: Aerial view of the mid-highlands near Kayamkulam**

**Zone 3**

The rugged topography of the Western Ghats mountain and the lower piedmont with an elevation ranging from 600 to 2500 m and 100 to 600m respectively. It occupies about 30% of the State's total area**.**

The result of the above two landforms between the Arabian Sea and mountains of the Western Ghats is that in the rainy season large areas are occupied by water bodies and several other areas with undulating terrain are inundated with water. So, only a small proportion of the land is free from water and inundation round the year. People in these regions live in scattered patches of high ground. The larger cities or towns like Thiruvananthapuram, Kollam, Kannur, Kottayam, Chengannur, and Thrissur have come up where there are large areas of high ground. Kochi / Ernakulam is a rare example of a large city built on low ground near the seacoast (with houses built on pile foundations), like Venice in Europe on the Adriatic Sea. There are very few large villages to be found in the mid-highlands, and hamlets are scattered all over wherever there is high ground to build houses that would be safe from the floodwaters. Between Kozhikode and Kasaragod, the midland topography of alternating mounds and waterlogged low ground is more pronounced. The towns and cities in the midlands here are small and more dispersed. For example, in the district Malappuram there are several towns like Malappuram itself, Kottakal, Manjeri, Tirur, Ponnani, Nilambur, and Valanchery, but none has a very large population. By contrast, the coastal belt has larger cities and there is less scattering of the urban population. (See the Google Earth image of the region near the north of Thiruvananthapuram **Figure 6.5).**

**Figure 6-5: Aerial image in the north of Thiruvananthapuram**

The above aerial image in the north of Thiruvananthapuram shows how inhabitations have grown parallel and close to the highways and other roads which are built on the higher ground.

In view of the above, alignment for a high speed line in such terrain and climatic area has to be designed very carefully to ensure its safety at all times.

## 6.2 PRINCIPLES FOR DECIDING THE ALIGNMENT

Based on various discussions with K-Rail on alignment issues, the following general principles are followed to design the SilverLine alignment to connect important cities and activity centres of the State;

i. Alignment to connect important cities / activity centres / commercial and industrial points.
ii. Alignment to follow and be by the side of the existing railway lines as much as possible to minimize land acquisition based on the directions from Govt of Kerala.
iii. Alignment to be chosen through such a route that it causes minimum disturbance to the public with least property and religious structures dislocation.
iv. Alignment to have desired traffic integration with Indian Railways, Metro and Kochi & Thiruanantapuram Airports in Kerala .
v. Alignment to pass through the less costly areas of land.
vi. Alignment to be economical, safe, easy to construct & maintain and durable.
vii. Alignment to permit desired operational speed of 200 Kmph.
viii. Alignment not to disturb the eco-system in the State.
ix. Alignment not to divide the lands of the State into two separate regions affecting its future growth.

### 6.2.1 Methodology for the study team to design the alignment

Adopting the above principles as strategies and guidelines, the design team aimed to design a techno-economic alignment on the route connecting important points indicated by K-Rail. Following have been the main technical factors and challenges which played an important role while designing the alignment.

**Technical factors:**

- Alignment not to affect too many land and properties
    - It should be by the side of existing IR's rail lines so that the requirement of new land is minimum.
    - High embankment or cutting to be avoided.
    - Entrapping of land to be avoided.
- Alignment to have minimum numbers of curves & grades to get the desired speed.
    - The general placement and direction of alignment will largely depend on the main natural and human barriers to be crossed and the obligatory points if any. For example, in the case of a line meant primarily for passenger services in a

corridor (which is the case with the subject SilverLine), the general direction and placement of the alignment will depend on how best to carry the line nearer to the densely populated core of the cities with minimum disturbance and at the same time with less numbers of curves and gradients.

 - Alignment has to be carefully chosen to be on straight at most of the locations to attain the desired speed.
 - Alignment has to utilise less intensively used lands not to affect the agricultural potential of the State, apart from not dislocating the households in large numbers.

- Alignment to have minimum numbers of tunnels, major bridges and viaducts length to get economical design.
  - In regions of adverse terrain, geological and geotechnical conditions, it must be ensured that alignment does not require the construction of large bridges, high viaducts and high embankments in areas with low bearing capacity, high cuttings in the landslide-prone slopes and tunnels in the collapsible rocky strata.
  - Very long & costlier bridges across large water bodies and backwaters are to be avoided. Alignment along coastal line may encounter back water areas.

- Alignment to be safe from the landslide in cuttings or embankment failure during operation.
  - Within the constraints of the obligatory points for the line, the alignment preferably to be located as to avoid the terrains that are inherently unsuitable for laying a high-speed railway line, such as landslide-prone areas and unstable hill slopes, geological fault lines and other major discontinuities, marshy ground and waterlogged areas, etc. At unavoidable sections where the alignment must pass through such areas due to site constraints, then its cost-effective engineering solution must be done during the execution of the project to avoid any adverse conditions after construction.

- Alignment to be easy to construct.
  - Smaller structures with less cost, are easier to construct and put lesser load and pressure on the ground. As, at this stage it is difficult to judge about the geology of the region correctly, due care is to be taken during execution of the project for all such structures by engaging the expert agencies as DDCs directly or in the scope of EPC contract.
  - Availability of Moorum / Gravel & Good Earth required for construction of the embankment has better availablity in mid Kerala.

- Alignment to pass through mid of the catchment of the population to the best extent to get more traffic and make the project more useful and financially viable.

  - Alignment proposed through the mid portion of any developing State will fetch more passenger traffic from both the sides (East-West) of the corridor through feeder services by road across. The alignment through coastal line will fetch the traffic from one side only. Therefore, it is desirable to adopt midlands route if possible.
- Alignment connecting important locations of the project to serve maximum population conveniently.
  - Apart from connectivity to major cities & towns like Kollam, Chengannur, Ernakulam, Thrissur, Tirur, Kozhikode and Kannur, it is desirable that the interior districts of Pathanamthitta and Idukki to have SilverLine connectivity either directly or through linking road network if possible. For this purpose the alignment through midlands will be more desirable.
- Alignment not to divide the State in to two
  - Providing adequate cross passages across the alignment wherever passages already exist and also at a few other places for the benefit of local public.
- Alignment to be built at a safe level to avoid any submergence of the track during the flood.

**Other challenges:**

- Difficult terrain and geology of the State: Requiring frequent turns of the alignment to avoid heavy bank / cutting, Cut & Cover, Viaducts and Tunnels.
- Heavy rains and floods: Importance in deciding the Rail level above HFL at all the places and designing alignment in flood prone areas carefully.
- The dispersed urban population in the State, with even the biggest cities having less population requires careful consideration for the selection of the route causing least disturbance to the public.
- Cost of the land required for the alignment and stations: To explore the route for alignment to pass through less costly areas.
- Minimum impact on the environment (forests and the wildlife, streams and other water bodies, fragile biospheres) also need to be carefully seen.

**Field visits and firming up of optimum alignment for SilverLine:**

The alignment team has carried out several field inspections to assess ground conditions, population patterns and other features like critical sections and identify locations / regions that would be prone to landslides, flood, tidal waves and tsunamis and other natural calamities to take a necessary call on the carefulness while designing the alignment.

Based on the obligatory points indicated by K-Rail along with the tentative route, to economise the cost of the project, the default choice has been to keep the alignment in bank or cutting mostly. However, based on the designer's experience on Indian railways and also based on experiences from other major infrastructural projects in the country, viaduct of nominal heights of about 8-15 m has been considered wherever required as per site constraints. At only unavoidable locations, the height of viaduct is relaxed upto 20m for only short stretches to avoid provisions of tunnels and so as to minimise the cost. Wherever required, the road crossings have been proposed through subways to minimise the height of bank / viaducts or depth of cuttings. Fine tuning of the alignment to minimise the heights of bank / viaducts or depth of cuttings or length of tunnels has been done based on detailed topographical survey plans.This will further require a critical review and detailed design before execution due to site and geological complexity.

Considering above parameters and challenges, following strategies have been evolved for desired track supporting structures for alignment design;

- **Alignment at At Grade- Embankment and Cutting:**
  Bank height and cutting depth not to be more than 8m and 9m respectively in normal cases.

- **Underground- Cut & cover and Tunnels:**
  Cut and cover has been considered for depth exceeding 9m and tunnel if the depth is more than 20m and ground has adequate cover.

- **Elevated-Viaduct and bridges:**
  Viaduct has been limited for some of the locations like where bank exceeds 8m height, slushy and flood prone stretches, habitated areas etc.

## 6.3 ALTERNATIVES OF ALIGNMENT AND RECOMMENDATION

**6.3.1** Basic priority for selecting the SilverLine alignment has been to keep the alignment along the existing railway lines. In view of general principles and other technical parameters, the alignments for Silver line project has been explored and studied with the following two major alternatives to get the best suited alignment.

In view of general principles and other technical parameters, the routes for Silver line project has been explored and studies with following two possibilities to get best suited alignment ;

a) Alternative 1: Alignment along existing railway lines i.e. through Midlands
b) Alternative 2: Alignment along coastal line

Both the alternatives as shown in the **Figure 6.6** are more or less along the existing railway lines. Alternative 1 is along the midlands being more along the existing railway lines to follow the general principles of the design of the project whereas the Alternative

2 is more close to coastal line. This has been further discussed in more details to get more insight of both the alternatives and comparison discussed as follows;


**Figure 6-6: Two Alternatives for SilverLine alignment**

### A. Alternative 1: Alignment along existing railway lines i.e. through Midlands

This alternative has been studied for the possibility of keeping the SilverLine along the existing railway lines as shown in the **Figure 6.6**. Careful examination of the existing railway lines from Kochuveli to Tirur reveals that this sector has frequent turns whereas the Tirur to Kasaragod section is comparatively better. It is clear from the following details;

**Table 6-1: Summary of horizontal curves on existing railway line**

| S.No | Section | No of horizontal curves on existing Rly lines | | |
|---|---|---|---|---|
| | | <1850m Radius | > 1850m Radius | Total |
| 1 | Kochuveli - Tirur | 254 | 68 | 322 |
| 2 | Tirur - Kasaragod | 77 | 58 | 135 |

If the alignment is kept truly along the existing railway lines following the sharp curves, it is not possible to get the desired speed of 200 kmph on the SilverLine and there would be a number of speed restrictions at several places, even to the extent of 50-60 kmph which will defeat the purpose of the Semi High Speed Rail Corridor planned. If the alignment is designed along the existing lines with the desired speed, then all the curves have to be realigned and provided with 1850m radius or more. This will involve several diversions for the line requiring huge land acquisition in new localities and causing entrapping of land and properties between the existing railway lines and the proposed SilverLine at many locations. This will not only result into wastage of parcels of land entrapped between both the lines but also increase the cost substantially.

**Options:**

Therefore, in order to determine the optimum alignment under Alternative 1 for the proposed SilverLine, three options have been studied and discussed for better understanding and taking appropriate decision. These options are as follows;

**Option 1:** Alignment from Thiruvananthapuram to Tirur through new areas and from Tirur to Kasaragod along existing railway lines *(With no compromise on the SilverLine speed)*

**Option 2:** Alignment fully along existing railway lines from Thiruvananthapuram to Kasaragod *(Sectional speed to be compromised and speed restrictions to be imposed at many locations)*

**Option 3:** Alignment fully along existing railway lines but as per SilverLine design parameters.*(With no compromise on the SilverLine speed but creates implications of land entrapping and property acquisition)*

**Table 6-2: Comparison of all three options of Alternative-1**

| S.No. | Criteria | Option-1 | Option-2 | Option-3 |
|---|---|---|---|---|
| 1 | Approximate location of alignment in respect to Existing railway lines | • Thiruvananthapuram to Tirur through new areas<br>• Tirur to Kasaragod along existing railway lines | Along existing railway lines in most of the locations with sharp curves | Along existing railway lines with deviations at sharp curve locations |
| 2 | Speed | 200Kmph | 200Kmph with number | 200Kmph |

| S.No. | Criteria | Option-1 | Option-2 | Option-3 |
|---|---|---|---|---|
| | | | of speed restrictions | |
| 3 | Speed restrictions | Nil ( expect at some station locations) | Yes at many locations | Nil (except at some station locations) |
| 4 | Land entrapping on sharp curves | No | No | Yes, several property involving huge areas at sharp curve locations will be entrapped. |
| 5 | Serves new areas | Yes | No | No |
| 6 | Property and land acquisition | Minimum | More than Option-1 (due to close vicinity of the railway line and existing structures) | Maximum (due to wastage of land and properties on entrapping of land locations) |
| 7 | Length of alignment passes through lesser costly land areas such as wet land and paddy field | 140 km | Nil | Nil |
| 8 | Actual length of the SilverLine alignment that could be planned along existing railway lines | 179Km | 577 Km (route length also will be more) | 575 Km (route length also will be more) |
| 9 | Overall | Recommended | Not desirable (due to speed restrictions) | Not desirable (due to extra cost and inconvenience to public due to wastage of land and properties entrapping at many places) |

In view of the several important aspects as discussed above, it is obvious that the SilverLine alignment cannot be planned fully along the existing railway lines. Therefore,

the Alternative Option-1 is preferable for further comparison with Alternative-2 and the same is described as under;

- Thiruvanthapuram to Tirur through new areas : 310 Km
- Tirur to Kasaragod along existing railway lines: 220 Km

**SilverLine alignment from Thiruvananthapuram to Tirur as a new green field corridor in Alternative-1:-**

SilverLine alignment starts from Thiruvanthapuram near Kochveli station of IR and traversers towards Kasaragod through new areas as it has not been possible to keep along the existing railway line due to sharp curves. The alignment has been selected to connect important locations strictly adopting the technical factors discussed in para no.6.2.1 above and passes through less congested, lesser costly land, avoiding flood prone areas like water bodies and back waters, hillocks, deep valleys and religious establishments.

**SilverLine alignment from Tirur to Kasaragod along existing railway lines in Alternative-1**

In this section, the alignment more or less is along the existing railway lines. The alignment passes through Tirur near the existing railway station of IR and traverses towards Kasaragod parallel to the existing railway lines. At some of the critical and unavoidable locations where it is not possible to keep the alignment parallel to the existing railway lines, the alignment has been designed by taking through less congested, lesser costly land and avoiding eco-sensitive areas and religious structures duly connecting the important locations.

**B. Alternative 2: Alignment along coastal line**

This alternative as shown in the Figure 6.6 had been explored in March 2019 along the coastal line to see the possibilities of having the alignment on less graded plains and to have an assessment of comparison of issues involved in these two routes. Main purpose is to see which route is advantageous. In this alternative 2, keeping alignment close to the existing railway lines for saving land and reducing acquisition related issues is not possible and hence not followed strictly. However, the alignment beyond Tirur is almost same as in alternative 1, though with some deviations for technical reasons.

**6.3.2** A techno-economic comparison of the two alternative alignments described above is given in Table 6.3 below for ready reconnaissance.

**Table 6-3: Comparison of Alternative-1 and Alternative-2**

| S.No | ALIGNMENT IN MID HIGHLANDS | ALIGNMENT IN COASTAL BELT |
|---|---|---|
| 1 | Less inconvenient to the public as only around 9314 structures and 9 religious structures are estimated to be relocated | Requires around 9827 structures and 27 other religious structures around to be relocated, so more inconvenient to the public |

| S.No | ALIGNMENT IN MID HIGHLANDS | ALIGNMENT IN COASTAL BELT |
|---|---|---|
| 2 | Design of the alignment is strictly in accordance with the general principle of the design as per directive of the government to be along the existing railway lines. It is along the existing railway lines for about 179Km | The alignment moves along the Coastal line. It is along the existing railway lines for about 42Km only |
| 3 | Utilisation of railway land is more due to more length along the existing railway lines | Comparatively less |
| 4 | It has been designed avoiding water bodies, back water areas and long bridges | As the alignment is more close to sea, the nos and length of water bodies and back water areas is more |
| 5 | Length of viaduct is less (Viaduct length-88.412 Km) and hence lesser cost. | Length of viaduct is more due to being more close to the sea and with crossing more water bodies the cost is more. (Viaduct length-212Km) |
| 6 | As the alignment has to pass through alternating sequence of hillocks and mounds and lowlands, careful technical consideration for safe design of the formation is required | Coastal line has comparatively flatter ground and hence less viaducts. Still as the alignment has to pass through back waters, complex designs will be required. |
| 7 | The alignment connects most of the cities and activity centres in the State including Kochi airport. | The alignment does not connect all important city centres. Kochi airport is also not connected. |
| 8 | No disturbance to fishing community areas and protected/ reserved areas. | Has to cross the fishing community areas at few places. |
| 9 | The route length is 529.450 Km | The route length is 532.7 Km |
| 10 | Away from Coastal line so no risk of tsunami like waves and less sea corrosion effects. | Requires more careful designing of levels and more corrosion prone. |
| 11 | Normal precautions and protective measures required. | Being close to the sea, need to augment safety against high winds and flooding of the rivers and back waters in the rainy season. |
| 12 | Provides passenger interchange to IR network at Kochuveli, Thrissur, Kozhikode, Kannur , Kasaragod and Kochi Metro Integration at Ernakulam (Kakanad). | Provides passenger interchange to IR network only at Kochuveli, Thrissur,& Kasaragod. |
| 13 | No costal regulatory zone issues involved. | Alignment being close to the Coast line CRZ restrictions will involve. |
| 14 | No speed restrictions are involved except at few stations approaches. | Speed restrictions are involved at 23 locations including in mid-sections. |
| 15 | Overall economical (Cost per route km. 120 Cr. approximately) | Comparatively costlier (Cost per route km. 150cr. approximately). |

### 6.3.3 Recommendation for alignment

Based on the reasoning given above and after due diligence on all issues and after detailed presentations and consultations with K-Rail, alignment in Alterrnative-1, i.e. the midland new alignment between Thiruvananthapuram and Tirur and parallel to and along existing rail alignment between Tirur and Kasaragod is found acceptable mainly from the points of view of better utility to the State, less inconvenience to the public and less initial cost of construction.

**6.3.4** The detailed descriptions of the alignment under Alternative-1 is given in para no.6.5 of this chapter.

## 6.4 GEOMETRIC DESIGN NORMS ADOPTED FOR DESIGN OF SilverLine

The geometrical design norms for horizontal and vertical alignment designs are based on the international practices adopted for similar Railway systems with standard gauge to have an operating speed of 200Kmph. However the geometrical design is done with the perspective of introduction of high speed tilting train up to 250 Kmph at a later stage.

### 6.4.1 Norms for horizontal alignment design

**Minimum Radius:**

Horizontal alignment has been designed for the operational speed of 200 Kmph (with potential speed of 250Kmph for tilting trains). Design parameters adopted for the design of horizontal alignment are the same as being followed for similar projects worldwide. Thus, the radius desirable for the centreline of the system for such high speed works out to 1850 m as given in the **Table 6.4.**However, in the close vicinity of stations for the purpose of obtaining proper connectivity, limiting value of 650 m radius is adopted at a few station~~s~~ approaches.

**Table 6-4: Minimum radius of alignment**

| | **Radius (All Main Line Section)** |
|---|---|
| **Normal:** | 1850 m and above |
| **Minimum:** | 650 m at station approaches within 2km |
| **Stations** | Preferably on straight |
| | **Radius (Non running lines)** |
| **Minimum :** | 190 m |

**Horizontal Curves**:

Horizontal curves are required to be provided with maximum radius or minimum curvature in their circular portion over specified lengths for obtaining necessary deviation angles for routing the alignment appropriately. Flatter curves with higher radius permits higher speeds subject to limitations over their transition portions. However very high radii require

longer curve lengths to achieve the same deviation. Hence designs call for a balanced approach. High Speed Railways go for flat curves of 6000 to 7000m radii as they are normally made on green fields. Kerala's Semi High Speed SilverLine is expected to pass through well developed cities and habitations, hence following such norms is extremely difficult here. An optimum radius is hence required to route the alignment without too much disturbing the developed areas and simultaneously achieving an ideal speed required to meet the project demand of covering the total distance in 3 ½ to 4 hours.

For radius on horizontal circular curves EN Code 13803-1 -2010(E) describes as under*;*

As per EN code 5.2.1 Radius of horizontal curve (R)

Largest curve radii and transition permitted by track design constraints should be used where possible. Normal limit for radius is 190 m and exceptional limit is 150m. Note that this small radii will result in a permissible speed less than 80 km/hour. Hence, normal and exceptional limit of radius shall also be derived from the requirements below.

The parameters shall be considered in the determination of the minimum curve radius are;

- The maximum and minimum speed;
- The applied cant;
- The limits for cant deficiency and cant excess.

For every combination of maximum speed $V_{max}$ and maximum cant deficency $I_{lim}$, the minimum permissible curve radius shall be calculated using the following equation;

$R_{min} = C_{lim} \times (V_{Max})^2 / (D + I_{Max})$

Where C = 11.8 ( 'R' =Minimum Radius, 'C'= 11.8 is a constant,

'V' = Maximum Speed, 'D' = Cant, 'I' = Maximum cant deficency

Therefore $R_{min} = 11.8 \times 200^2 / (160+100)$

= 1815.4 m or Say **1850m** is adopted for minimum radius for 200 Kmph

EN permits a normal limit of 160mm and exceptional limit of 180mm for cant. Cant gets restricted by small radius curves, cant excess problems and high differential speed of trains. Similarly EN permits a normal limit of 130mm and exceptional limit of 168mm for cant deficiency (for 200kmph non-tilting trains). For tilting trains, it permits much higher values for Cant deficiency. Accordingly, the following provisions are planned in the project.

Maximum permissible cant (Ca) :160 mm

Maximum cant deficiency (Cd) :100 mm for normal coaches and 240 mm for tilting coaches

Maximum cant excess (Ce) :100 mm (To be reviewed later when goods trains are introduced with their minimum speed in the section

Based on the above guidelines, with the indicated values of cant Ca of 160mm and cant deficiency Cd of 100 mm, a maximum radius of 1850m is proposed for the horizontal curves in the SilverLine corridor.

Equilibirium Speed for SG track with the above norms is given by - Vmax = 0.29x Sqrt {R x (Ca+Cd)}; (R in m, Ca & Cd in mm). Vmax for SilverLine = 0.29x sqrt {1850x(160+100)} = 201 Kmph.

**Note:** The radius of 1850m is considered ideal for the reasons explained earlier. However for the Corridor's Design Speed of 220 Kmph, a radius of 2200 m is required theoretically. CEN, UIC 518 and other guidelines permit adoption of marginally higher speed which is lower of 110% of permissible speed (or) the speed corresponding to 110% of permissible cant deficiency for testing. Allowances for installation / maintenance can be managed by better maintenance. After a few years of operation, sustaining the prescribed operational speed will be possible by permitting marginal increase in cant deficiency if required.

Further running of trains in the sections particularly on curves will be characterised by the riding quality achievable. With proper maintenance, riding quality of a minimum of Ride Index of 2.5 (both vertical and lateral) at speed of 200 Kmph on 1850m radius curves will be possible.

**Transition curve lengths :**

Transition curve length of horizontal curves are designed for varius radii based on the alignment design parameters as given below**.** Minimum length of the transition curves is maintained as 100m.

The following formulae for transition curve length are based on EN Code No 13803-1:2010(E).The maximum of the three values, (L1, L2 & L3) for transition length given in the table should be adopted.( With sample calculation for 1850m radius).

| SL. No. | Recommendation as per EN Code | Formule | Minimum TL (As per normal limits) | Cant Gradient |
|---|---|---|---|---|
| 1 | Cant gradient<br>1) Normal limit = 2.25 mm/m<br>2) Exceptional limit = 2.5 mm/m | L1=0.444xCa | 0.444x160<br>= 71.04m | - |
| 2 | Rate of change of Cant (Ca)<br>1) Normal limit =50mm/sec<br>2) Exceptional limit = 60 mm/sec | L2=0.00555xCaxVm | 0.00555x160x200<br>=177.6m,say180m | 1 in 1125 |

| SL. No. | Recommendation as per EN Code | Formule | Minimum TL (As per normal limits) | Cant Gradient |
|---|---|---|---|---|
| 3 | Rate of change of Cant Deficiency (Cd)<br>1) Normal limit = 55 mm/sec<br>2) Exception limit = 75 mm/sec | L3=0.0051xCdxVm | 0.0051x100x200 =102m | - |

**Table 6-5: Transition curve length calculation**

| Curve calculation with limiting parameters of Ca, Cd, & Ce (160,100 &100 For Passenger Trains and RORO Trains) for Radius 650-15000 m for a Maximum Speed of 200 Kmph using EN Formulas | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Transition length in m according to European Standard | | | | | Check For Goods Trains Speed 120 Kmph. | | | | |
| Serial No | Gauge in mm | Degree of Curve | Radius in m | Max: Speed allowed with max: Cd of 100 mm=0.29*(Sqrt*R(Ca+Cdmax)) | Desirable Speed | Provided cant in mm | Equ. Cant=GV*V/127 R in mm | Cant Diff:Cd= Max: 100 mm | 0.4444ca | 0.00555 Ca*Vm | 0.0051 Cd*Vm | Max: of Column Nos 9-11 is to be adopted | Max :to be adopted rounding off to nearest higher multiples of 10 mm subject to a minimum of 100 m | Speed in Kmph | Cant in mm= G*V*V/127/R | (Cant deff:)Cd=Max:100 mm) | (Cant excess)Ce= Max:100 mm | Actual uncompensated lateral Acceleration max:(0.7m/sec²=(g/(G*Cd )m/sec²) |
| | G | D | R | | | Ca | C Eq. | Cd | | | | | | | | | | |
| Col: No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 1 | 1507 | 2.692 | 650 | 119 | 115 | 160 | 241 | 81 | 71 | 102 | 48 | 102 | 110 | 115 | 241 | 81 | -81 | 0.53 |
| 2 | 1507 | 2.5 | 700 | 124 | 120 | 160 | 244 | 84 | 71 | 107 | 51 | 107 | 110 | 120 | 244 | 84 | -84 | 0.55 |
| 3 | 1507 | 2.188 | 800 | 132 | 130 | 160 | 251 | 91 | 71 | 115 | 60 | 115 | 120 | 120 | 214 | 54 | -54 | 0.59 |
| 4 | 1507 | 1.944 | 900 | 140 | 140 | 160 | 258 | 98 | 71 | 124 | 70 | 124 | 130 | 120 | 190 | 30 | -30 | 0.64 |
| 5 | 1507 | 1.75 | 1000 | 148 | 145 | 160 | 249 | 89 | 71 | 129 | 66 | 129 | 130 | 120 | 171 | 11 | -11 | 0.58 |
| 6 | 1507 | 1.591 | 1100 | 155 | 155 | 160 | 259 | 99 | 71 | 138 | 78 | 138 | 140 | 120 | 155 | -5 | 5 | 0.65 |
| 7 | 1507 | 1.458 | 1200 | 162 | 160 | 160 | 253 | 93 | 71 | 142 | 76 | 142 | 150 | 120 | 142 | -18 | 18 | 0.61 |
| 8 | 1507 | 1.346 | 1300 | 169 | 165 | 160 | 249 | 89 | 71 | 147 | 74 | 147 | 150 | 120 | 131 | -29 | 29 | 0.58 |
| 9 | 1507 | 1.25 | 1400 | 175 | 175 | 160 | 260 | 100 | 71 | 155 | 89 | 155 | 160 | 120 | 122 | -38 | 38 | 0.65 |

**Curve calculation with limiting parameters of Ca, Cd, & Ce (160,100 &100 For Passenger Trains and RORO Trains) for Radius 650-15000 m for a Maximum Speed of 200 Kmph using EN Formulas**

| Serial No | Gauge in mm | Degree of Curve | Radius in m | Max: Speed allowed with max: Cd of 100 mm=0.29*(Sqrt*R(Ca+Cdmax)) | Desirable Speed | Provided cant in mm | Equ. Cant=GV*V/127 R in mm | Cant Diff:Cd= Max: 100 mm | Transition length in m according to European Standard: 0.4444ca | 0.00555 Ca*Vm | 0.0051 Cd*Vm | Max: of Column Nos 9-11 is to be adopted | Max :to be adopted rounding off to nearest higher multiples of 10 mm subject to a minimum of 100 m | Check For Goods Trains Speed 120 Kmph.: Speed in Kmph | Cant in mm= G*V*V/127/R | (Cant deff:)Cd=Max:100 mm) | (Cant excess)Ce= Max:100 mm | Actual uncompensated lateral Acceleration max:(0.7m/sec²=(g/(G*Cd )m/sec²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G | D | R | | | Ca | C Eq. | Cd | | | | | | | | | | |
| Col: No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 10 | 1507 | 1.167 | 1500 | 181 | 180 | 160 | 256 | 96 | 71 | 160 | 88 | 160 | 160 | 120 | 114 | -46 | 46 | 0.63 |
| 11 | 1507 | 1.094 | 1600 | 187 | 185 | 160 | 254 | 94 | 71 | 164 | 89 | 164 | 170 | 120 | 107 | -53 | 53 | 0.61 |
| 12 | 1507 | 1.029 | 1700 | 193 | 190 | 160 | 252 | 92 | 71 | 169 | 89 | 169 | 170 | 120 | 101 | -59 | 59 | 0.6 |
| 13 | 1507 | 0.972 | 1800 | 198 | 195 | 160 | 251 | 91 | 71 | 173 | 90 | 173 | 180 | 120 | 95 | -65 | 65 | 0.59 |
| 14 | 1507 | 0.946 | 1850 | 201 | 200 | 160 | 257 | 97 | 71 | 178 | 98 | 178 | 180 | 120 | 92 | -68 | 68 | 0.63 |
| 15 | 1507 | 0.921 | 1900 | 204 | 200 | 160 | 250 | 90 | 71 | 178 | 92 | 178 | 180 | 120 | 90 | -70 | 70 | 0.58 |
| 16 | 1507 | 0.875 | 2000 | 209 | 200 | 160 | 237 | 77 | 71 | 178 | 79 | 178 | 180 | 120 | 85 | -75 | 75 | 0.5 |
| 17 | 1507 | 0.833 | 2100 | 212 | 200 | 155 | 226 | 71 | 69 | 172 | 72 | 172 | 180 | 120 | 81 | -74 | 74 | 0.46 |
| 18 | 1507 | 0.795 | 2200 | 215 | 200 | 150 | 216 | 66 | 67 | 167 | 67 | 167 | 170 | 120 | 78 | -72 | 72 | 0.43 |
| 19 | 1507 | 0.778 | 2250 | 215 | 200 | 145 | 211 | 66 | 64 | 161 | 67 | 161 | 160 | 120 | 76 | -69 | 69 | 0.43 |

**Curve calculation with limiting parameters of Ca, Cd, & Ce (160,100 &100 For Passenger Trains and RORO Trains) for Radius 650-15000 m for a Maximum Speed of 200 Kmph using EN Formulas**

| Serial No | Gauge in mm | Degree of Curve | Radius in m | Max: Speed allowed with max: Cd of 100 mm=0.29*(Sqrt*R(Ca+Cdmax)) | Desirable Speed | Provided cant in mm | Equ. Cant=GV*V/127 R in mm | Cant Diff:Cd= Max: 100 mm | Transition length in m according to European Standard | | | | | Check For Goods Trains Speed 120 Kmph. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 0.4444ca | 0.00555 Ca*Vm | 0.0051 Cd*Vm | Max: of Column Nos 9-11 is to be adopted | Max :to be adopted rounding off to nearest higher multiples of 10 mm subject to a minimum of 100 m | Speed in Kmph | Cant in mm= G*V*V/127/R | (Cant deff:)Cd=Max:100 mm) | (Cant excess)Ce= Max:100 mm | Actual uncompensated lateral Acceleration max:(0.7m/sec²=(g/(G*Cd )m/sec²) |
| | G | D | R | | | Ca | C Eq. | Cd | | | | | | | | | | |
| Col: No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 20 | 1507 | 0.7 | 2500 | 220 | 200 | 130 | 190 | 60 | 58 | 144 | 61 | 144 | 150 | 120 | 68 | -62 | 62 | 0.39 |
| 21 | 1507 | 0.636 | 2750 | 226 | 200 | 120 | 173 | 53 | 53 | 133 | 54 | 133 | 140 | 120 | 62 | -58 | 58 | 0.34 |
| 22 | 1507 | 0.583 | 3000 | 230 | 200 | 110 | 158 | 48 | 49 | 122 | 49 | 122 | 130 | 120 | 57 | -53 | 53 | 0.31 |
| 23 | 1507 | 0.5 | 3500 | 240 | 200 | 95 | 136 | 41 | 42 | 105 | 41 | 105 | 110 | 120 | 49 | -46 | 46 | 0.26 |
| 24 | 1507 | 0.438 | 4000 | 246 | 200 | 80 | 119 | 39 | 36 | 89 | 39 | 89 | 100 | 120 | 43 | -37 | 37 | 0.25 |
| 25 | 1507 | 0.389 | 4500 | 257 | 200 | 75 | 105 | 30 | 33 | 83 | 31 | 83 | 100 | 120 | 38 | -37 | 37 | 0.2 |
| 26 | 1507 | 0.35 | 5000 | 263 | 200 | 65 | 95 | 30 | 29 | 72 | 31 | 72 | 100 | 120 | 34 | -31 | 31 | 0.19 |
| 27 | 1507 | 0.318 | 5500 | 272 | 200 | 60 | 86 | 26 | 27 | 67 | 27 | 67 | 100 | 120 | 31 | -29 | 29 | 0.17 |
| 28 | 1507 | 0.292 | 6000 | 275 | 200 | 50 | 79 | 29 | 22 | 56 | 30 | 56 | 100 | 120 | 28 | -22 | 22 | 0.19 |
| 29 | 1507 | 0.269 | 6500 | 286 | 200 | 50 | 73 | 23 | 22 | 56 | 23 | 56 | 100 | 120 | 26 | -24 | 24 | 0.15 |

| Curve calculation with limiting parameters of Ca, Cd, & Ce (160,100 &100 For Passenger Trains and RORO Trains) for Radius 650-15000 m for a Maximum Speed of 200 Kmph using EN Formulas | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Transition length in m according to European Standard | | | | | Check For Goods Trains Speed 120 Kmph. | | | | |
| Serial No | Gauge in mm G | Degree of Curve D | Radius in m R | Max: Speed allowed with max: Cd of 100 mm=0.29*(Sqrt*R(Ca+Cdmax)) | Desirable Speed | Provided cant in mm Ca | Equ. Cant=GV*V/127 R in mm C Eq. | Cant Diff:Cd= Max: 100 mm Cd | 0.4444ca | 0.00555 Ca*Vm | 0.0051 Cd*Vm | Max: of Column Nos 9-11 is to be adopted | Max :to be adopted rounding off to nearest higher multiples of 10 mm subject to a minimum of 100 m | Speed in Kmph | Cant in mm= G*V*V/127/R | (Cant deff:)Cd=Max:100 mm) | (Cant excess)Ce= Max:100 mm | Actual uncompensated lateral Acceleration max:(0.7m/sec²=(g/(G*Cd )m/sec²) |
| Col: No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 30 | 1507 | 0.25 | 7000 | 292 | 200 | 45 | 68 | 23 | 20 | 50 | 23 | 50 | 100 | 120 | 24 | -21 | 21 | 0.15 |
| 31 | 1507 | 0.233 | 7500 | 297 | 200 | 40 | 63 | 23 | 18 | 44 | 24 | 44 | 100 | 120 | 23 | -17 | 17 | 0.15 |
| 32 | 1507 | 0.219 | 8000 | 307 | 200 | 40 | 59 | 19 | 18 | 44 | 20 | 44 | 100 | 120 | 21 | -19 | 19 | 0.13 |
| 33 | 1507 | 0.206 | 8500 | 316 | 200 | 40 | 56 | 16 | 18 | 44 | 16 | 44 | 100 | 120 | 20 | -20 | 20 | 0.1 |
| 34 | 1507 | 0.194 | 9000 | 320 | 200 | 35 | 53 | 18 | 16 | 39 | 18 | 39 | 100 | 120 | 19 | -16 | 16 | 0.12 |
| 35 | 1507 | 0.184 | 9500 | 328 | 200 | 35 | 50 | 15 | 16 | 39 | 15 | 39 | 100 | 120 | 18 | -17 | 17 | 0.1 |
| 36 | 1507 | 0.175 | 10000 | 331 | 200 | 30 | 47 | 17 | 13 | 33 | 18 | 33 | 100 | 120 | 17 | -13 | 13 | 0.11 |
| 37 | 1507 | 0.159 | 11000 | 347 | 200 | 30 | 43 | 13 | 13 | 33 | 13 | 33 | 100 | 120 | 16 | -14 | 14 | 0.09 |
| 38 | 1507 | 0.146 | 12000 | 355 | 200 | 25 | 40 | 15 | 11 | 28 | 15 | 28 | 100 | 120 | 14 | -11 | 11 | 0.09 |
| 39 | 1507 | 0.135 | 13000 | 370 | 200 | 25 | 37 | 12 | 11 | 28 | 12 | 28 | 100 | 120 | 13 | -12 | 12 | 0.07 |

**Curve calculation with limiting parameters of Ca, Cd, & Ce (160,100 &100 For Passenger Trains and RORO Trains) for Radius 650-15000 m for a Maximum Speed of 200 Kmph using EN Formulas**

| Serial No | Gauge in mm | Degree of Curve | Radius in m | Max: Speed allowed with max: Cd of 100 mm=0.29*(Sqrt*R(Ca+Cdmax)) | Desirable Speed | Provided cant in mm | Equ. Cant=GV*V/127 R in mm | Cant Diff:Cd= Max: 100 mm | Transition length in m according to European Standard: 0.4444ca | Transition length in m according to European Standard: 0.00555 Ca*Vm | Transition length in m according to European Standard: 0.0051 Cd*Vm | Transition length in m according to European Standard: Max: of Column Nos 9-11 is to be adopted | Transition length in m according to European Standard: Max :to be adopted rounding off to nearest higher multiples of 10 mm subject to a minimum of 100 m | Check For Goods Trains Speed 120 Kmph.: Speed in Kmph | Check For Goods Trains Speed 120 Kmph.: Cant in mm= G*V*V/127/R | Check For Goods Trains Speed 120 Kmph.: (Cant deff:)Cd=Max:100 mm) | Check For Goods Trains Speed 120 Kmph.: (Cant excess)Ce= Max:100 mm | Actual uncompensated lateral Acceleration max:(0.7m/sec²=(g/(G*Cd )m/sec²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G | D | R | | | Ca | C Eq. | Cd | | | | | | | | | | |
| Col: No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 40 | 1507 | 0.125 | 14000 | 384 | 200 | 25 | 34 | 9 | 11 | 28 | 9 | 28 | 100 | 120 | 12 | -13 | 13 | 0.06 |
| 41 | 1507 | 0.117 | 15000 | 389 | 200 | 20 | 32 | 12 | 9 | 22 | 12 | 22 | 100 | 120 | 11 | -9 | 9 | 0.08 |

**Basis for calculation of transition lengths:**

Based on EN Code the following are the basis for calculation of transition curve length. Maximum of all the three values subject to a minimum of 100m has been recommended.

i. **Cant Gradient**
1) Normal = 2.25 mm /m
2) Exceptional =2.5 mm /m
Therefore cant gradient=1in1000/2.25=1 in 444
Transition length=**0.444 Ca ( Normal limit)**

or

ii. **Rate of change of Cant**
1) Normal = 50 mm / sec
2) Exceptional = 60 mm / sec
Therefore L2=1000/(50X3600)=**0.00555 x Ca x Vm (Normal Limit)**

or

iii. **Rate of change of Cant Deficiency (Cd)**
1) Normal = 55 mm /sec
2) Exception= 75 mm/sec
Therefore L3=1000/(55X3600) = **0.00505Ca x Vm or Say**
= **0.0051xCdxVm ( Normal limit)**

**General useful notes adopted for Horizontal alignment Design:**

- Minimum straight between two transition curves 100m.
- Minimum curve length between two transition curves in the middle of curves also is 100m.

**As per EN code**

In certain applications, the actual length of any alignment element (other than transition curves) should be set equal to or more as described hereunder, taking into account the actual alignment design parameters of the neighbouring alignment elements (cant, cant deficiency and their variations).

**Min length of alignment elements except TL as per EN Codes:-**

I. Upto 200Kmph = Vm/3 (normal limits), Vm/5 (Exceptional limits)
II. 200-300kmph = Vm/1.5 (normal limits), Vm/2.5 (Exceptional limits)

Hence the desirable value for 250 Kmph speed as given by 250/1.5 is 167m and the limiting value given by 250/2.5 is 100m.

Therefore the minimum element length is adopted as 100m. The straight in between two transition curves can be restricted to Zero if the length in between is less than the required limits .

However, for the speed less than 200Kmph where sharp curves may be required to be provided as per site constraints specially in the approach of the stations on SilverLine, the desirable value is V/3 and limiting value is V/5 as per EN Codes.

### 6.4.2 Norms for Vertical alignment design

Various parameters adopted for vertical alignment design are as follows;

**Gradients:**

Normally the stations shall be on level. In limiting cases station may be on a grade of 1.5‰(1 in 660) . Between stations, the grades shall not be steeper than 16.7 ‰ (i.e. 1 in 60).This will be the Ruling Gradient of the SilverLine . In connections to non-running line, it can be 25‰ (1 in 40). However, all the gradients in limiting gradients are compensated for the curves.

**Minimum radius for Vertical Curves:**

Vertical curves are to be provided when change in gradient exceeds 0.2‰. However, it is recommended to provide vertical curves at every change of gradient location.

There are many methods to calculate the minimum radius for vertical curves. After due diligence considering all results by these methods, desirable radius considered for the project is 17500 as deliberated hereunder;

a) **Minimum radius of vertical curves adopted based on EN 13803-1:2010(E) formula 0.35 V*V (where 0.35 is a constant and “V” is the maximum permissible speed.**

   R=0.35*V*V and V = 250 Kmph (considering future likely tilting train speed).
   R=0.35*250*250 = **21875 m**(based on desirable vertical acceleration of 0.022g).

b) **In exceptional cases radius may be restricted as detailed below (EN 13803-1:2010(E) formula)**

   Exceptional limit for radius of vertical curve is R =0.13 V*V for hollow vertical curves and 0.16 V*V for the crest.

   R=0.13*V*V for Hollow and R=0.16*V*V for Crest where **0.13 and 0.16** are constants and **V** is the maximum permissible speed 250 Kmphand R which works out to **8125m and 10000**m respectively (Based on limiting vertical acceleration of 0.04g).

c) **<u>Radius of vertical curve using Shinkansen formula</u>**
   In Shinkansen Railways the radius is limited to 15000m radius which is explained as follows,

   **Minimum Radius of Vertical Curve for Comfort:**

   - $R=V^2/(127 * a)$
   - Where ‘a’: vertical acceleration

   It is generally regarded that allowable value of vertical acceleration “a” is 0.05g(Shinkansen). In case of high-speed train, value of vertical acceleration “a” is approximately 0.033 g(Shinkansen). Accordingly, the values come to;

- R=250x250/(127x0.05)= 9842m or say **9900** m
- R=250x250/(127x0.033)=14913m or say **15000** m

**Table 6-6: Minimum Radius for Vertical Curve with Shinkansen formulae**

| A | 0.050g | | | 0.033g | | |
|---|---|---|---|---|---|---|
| V (km/h) | 200 | 250 | 300 | 200 | 250 | 350 |
| R (m) | 6,300 | **9,900** | 14,200 | 9,600 | **15,000** | 29,300 |

**Summing up on minimum vertical curve radius:**

The required minimum radius for vertical curves for 250 Kmph speed (considering tilting trains)c on the basis of calculations as shown above is summarized hereunder;

a) As per EN Formula
   - Desirable 21875m
   - 8125m and 10000m for exceptional locations

a) As per shinkansen formula
   - 15000m for vertical acceleration “a” as 0.05g
   - 9900m for vertical acceleration “a” as 0.033g

After due diligence of the aspects of train running safety, it has been decided that a vertical radius of 17,500m will be provided as desirable in the project and it will be reduced to bare minimum as 10,000 m in exceptional cases. The vertical curves proposed are simple circular curves and the magnitude of untamed vertical acceleration negotiating the vertical curves furnished below.

| Sl No. | Radius of vertical curve(m) | Speed (Kmph) | Vertical acceleration (m/s2) | Vertical acceleration in “g” |
|---|---|---|---|---|
| 1 | 10,000(limiting radius) | 200 | 0.309 | 0.03g |
| 2 | 10,000(limiting radius) | 250 | 0.482 | 0.049g |
| 3 | 17500(desirable min) | 200 | 0.176 | 0.018g |
| 4 | 17500 (desirable min) | 250 | 0.275 | 0.028g |

## 6.5 DESCRIPTION OF RECOMMENDED ALIGNMENT- MID-HIGH LANDS (AS PER ALTERNATIVE-1)

### 6.5.1 The Alignment for SilverLine

The alignment for SilverLine line has been planned keeping all the constraints of the region in the mind as discussed in the paragraphs above. Further details have been discussed hereunder.

Finding a way to carry a new Railway line to the city centres or as close to it as possible such that the city population can reach the station from within a short distance, has been often the most difficult part of the preparing a sound alignment considering all the factors as discussed above, Due to undulating topography and due to compulsion to keep the alignment economical, safe, desired connectivity with important points, avoiding critical locations, water bodies, unsafe areas, habitated areas and other constraints, various curves and gradients for horizontal and vertical alignment designs as described below are to be provided within the specified parameters. Plans and longitudinal sections indicating horizontal and vertical designs of alignment have been developed and enclosed with the DPR as Volume VI.

#### 6.5.1.1 Horizontal alignment design

Total 200 curves including 16 curves having radius less than 1850m are there in the alignment. All these sharp curves are on the approaches of the stations and hence will not affect the running time. The list of horizontal curves designed are furnished in the **Table 6.50.** The total length of these curves comes to 194.319Kms out of total length of 529.450 which works out to 36.7% (Route length is start to end corridor length is 532.185 Km).

#### 6.5.1.2 Vertical alignment design

Alignment designers prefer to provide flatter gradients as much as possible. However due to site constraints, gradients as per planning parameters have been proposed as shown in **Table 6.51**. The total number of change of gradients are 237 and 236 vertical curves between centre line of Thiruvananthapuram and Kasaragod station. Even though the ruling gradient planned is 1.67% (1 in 60) the maximum grade adopted is only 1.56% (1 in 62) and the maximum grade length is 2139m and hence there is no need for further compensating the gradients for the curves. All the vertical curves in the section have radii more than 17500m.

### 6.5.2 Route description of recommended alignment :-

The entire alignment has been divided into various sections, between the proposed stations. Section wise description is given below. Thiruvananthapuram - Kasaragod directional line is A line and the Kasaragod-Thiruvananthapuram directional line is B line as classified.

#### 6.5.2.1 Section-1: Thiruvananthapuram- Kollam

Thiruvananthapuram station is proposed on the eastern side of the existing Kochuveli Railway Station. It is kept parallel to the existing second terminal station of Thiruvananthapuram for integration with the existing railway station and it comes in between the existing Kochuveli Railway Station and the NH66 bye pass.

This station is planned at two levels in view of existing ground levels and water bodies in the area with station facilities in Level 1 and is provided with 4 Island Platforms of 410 m long and 11.32m wide (3 in the beginning and 1 in future ) with 6 passenger loops and 2 main lines(entry lines), 4 stabling lines and 1 tourist siding. RORO facility with 1 loop line on either side of the main line and 1 loading line with a 10m wide loading platform on B line side is planned slightly away towards Kollam station for want of adequate space in the area. This station is planned with integration with the Southern Railway's Kochuveli second terminal station .

The alignment starts from Thiruvananthapuram (Kochuveli) station at chainage 0.000, runs parallel in the eastern side of the existing railway lines, passes through green fields and reaches Kollam Station near Kollam NH-544 by pass at chainage 55338 at about 7 Km away from the existing Kollam Railway Station. On the way it crosses NH 544 at 4 locations at chainages 28532,44800,48538 and 50460. There are 21 Cut & cover locations for a length of 4.858 Km at the following locations as shown in **Table 6.7**. The alignment also crosses Major Rivers at 8 locations as furnished in **Table 6.8**. There are 3 Tunnels on the alignment as furnished in **Table 6.9**. There are 21 Viaduct locations on the alignment as furnished in **Table 6.10**

**Table 6-7: List of Cut and Cover locations**

| THIRUVANANTHAPURAM TO KOLLAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 16.660 | 17.015 | 0.355 |
| 2 | 20.571 | 20.722 | 0.151 |
| 3 | 21.281 | 21.430 | 0.149 |
| 4 | 25.138 | 25.254 | 0.116 |
| 5 | 26.340 | 26.575 | 0.235 |
| 6 | 27.400 | 27.825 | 0.425 |
| 7 | 27.995 | 28.180 | 0.185 |
| 8 | 29.880 | 30.215 | 0.335 |

| THIRUVANANTHAPURAM TO KOLLAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 9 | 31.150 | 31.502 | 0.352 |
| 10 | 31.800 | 31.945 | 0.145 |
| 11 | 33.482 | 33.700 | 0.218 |
| 12 | 34.000 | 34.135 | 0.135 |
| 13 | 34.684 | 34.850 | 0.166 |
| 14 | 35.350 | 35.431 | 0.081 |
| 15 | 35.700 | 36.010 | 0.310 |
| 16 | 36.850 | 37.180 | 0.330 |
| 17 | 39.824 | 39.909 | 0.085 |
| 18 | 42.310 | 42.473 | 0.163 |
| 19 | 42.910 | 43.128 | 0.218 |
| 20 | 44.466 | 44.900 | 0.434 |
| 21 | 50.860 | 51.130 | 0.270 |
| Total | | | 4.858 Km |

**Table 6-8: List of major rivers crossings**

| THIRUVANANTHAPURAM TO KOLLAM | | |
|---|---|---|
| S.No | Chainage | Name of River |
| 1 | 0.770 | Parvathy puthanar |
| 2 | 15.120 | Parvathy puthanar |
| 3 | 19.000 | Maamam River |
| 4 | 21.190 | Maamam River |
| 5 | 22.401 | Vamanapuram River |
| 6 | 23.005 | Vamanapuram River |

| THIRUVANANTHAPURAM TO KOLLAM | | |
|---|---|---|
| S.No | Chainage | Name of River |
| 7 | 24.500 | Vamanapuram River |
| 8 | 48.760 | Ithikar River |

**Table 6-9: List of tunnels locations**

| THIRUVANANTHAPURAM TO KOLLAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 33.700 | 34.000 | 0.300 |
| 2 | 34.850 | 35.350 | 0.500 |
| 3 | 40.200 | 40.400 | 0.200 |
| **Total** | | | **1.000 Km** |

**Table 6-10: List of Viaducts locations**

| THIRUVANANTHAPURAM TO KOLLAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | -1.100 | 0.770 | 1.870 |
| 2 | 0.862 | 1.612 | 0.750 |
| 3 | 17.850 | 18.810 | 0.960 |
| 4 | 20.100 | 20.490 | 0.390 |
| 5 | 28.760 | 29.090 | 0.330 |
| 6 | 33.230 | 33.440 | 0.210 |
| 7 | 35.475 | 35.625 | 0.150 |
| 8 | 36.210 | 36.360 | 0.150 |
| 9 | 36.550 | 36.730 | 0.180 |
| 10 | 38.450 | 39.260 | 0.810 |

| THIRUVANANTHAPURAM TO KOLLAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 11 | 39.970 | 40.120 | 0.150 |
| 12 | 41.200 | 41.590 | 0.390 |
| 13 | 42.100 | 42.310 | 0.210 |
| 14 | 42.473 | 42.713 | 0.240 |
| 15 | 43.480 | 43.690 | 0.210 |
| 16 | 45.240 | 45.660 | 0.420 |
| 17 | 46.910 | 47.150 | 0.240 |
| 18 | 48.852 | 49.782 | 0.930 |
| 19 | 50.280 | 50.550 | 0.270 |
| 20 | 51.340 | 52.240 | 0.900 |
| 21 | 52.900 | 54.400 | 1.500 |
| **Total** | | | **11.260 Km** |

#### 6.5.2.2 Section-2: Kollam- Chengannur

Kollam station is proposed at a distance of about 7 Km away from the existing Kollam Railway Station and is at grade, almost parallel to the recently opened NH-544 bypass, for want of suitable location at the city centre. One Depot with Workshop is also proposed at this station where there is sufficient private land available for acquisition However the place now proposed is a fast-developing area with lot of access to approach the station.

This station proposed at grade is provided with 4 island platforms 11.32m wide and 410m long with 2 loop lines on either side and 2 main lines in between, 2 RORO lines, 1 RORO loading line with 10m wide platform for loading,1 OHE Maintenance depot, 1 Engineering Maintenance depot and 1 Ballast depot.This station is also provided with a mechanical depot with IBL5 Nos, SBL 12 Nos, Workshop lines 6 Nos , 1 Pit Wheel line, 1 Heavy cleaning line, 2 RORO Stabling lines, 1 Paint Booth line 1 No, 1 Unloading Bay line,1 P. Way Siding ,1 BD Special line, 1 ARME line 270 m, 1 Test Track lineof 1760 mlength and 1 RRV siding of124 m length with shed.

Kollam depot with workshop facilities are located on the left hand side of the main line. Though the depot is located on the A line side, traffic planning has been made in such a

way that no train from B line will be required to be taken to the depot crossing the main lines except during exigencies.

The alignment further passes through green fields and reaches the proposed Chengannur Station at chainage 102900 near MC road at about 4.30 Km from the existing railway station. On the way the alignment crosses existing Kollam - Madurai highway at chainage 63000, Kollam – Punalur railway line at chainage 63100, highway 183A at chainage 77050, one pond of length 92m at chainage 76097 and MC Road at Chainage 102050. There are 16 Cut and covers for a length of 6.255 Km, 5 major rivers, 1 tunnels for a length of 0.800 Km and 16 viaducts for a length of 7.976 Km as furnished in **Tables 6.11 to 6.14.**

**Table 6-11: List of Cut and Cover locations**

| KOLLAM TO CHENGANNUR | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 62.970 | 63.580 | 0.610 |
| 2 | 64.905 | 65.460 | 0.555 |
| 3 | 68.260 | 68.634 | 0.374 |
| 4 | 69.015 | 69.385 | 0.370 |
| 5 | 69.950 | 70.500 | 0.550 |
| 6 | 72.326 | 72.550 | 0.224 |
| 7 | 79.356 | 79.788 | 0.432 |
| 8 | 81.620 | 81.800 | 0.180 |
| 9 | 83.730 | 84.080 | 0.350 |
| 10 | 88.270 | 88.510 | 0.240 |
| 11 | 97.091 | 97.260 | 0.169 |
| 12 | 97.430 | 99.185 | 1.755 |
| 13 | 99.386 | 99.432 | 0.046 |
| 14 | 100.240 | 100.440 | 0.200 |
| 15 | 100.550 | 100.600 | 0.050 |
| 16 | 101.400 | 101.550 | 0.150 |

| KOLLAM TO CHENGANNUR | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| **Total** | | | **6.255 Km** |

**Table 6-12: List of Major Rivers**

| KOLLAM TO CHENGANNUR | | |
|---|---|---|
| S.No | Chainage | Name of River |
| 1 | 70.896 | Kallada River |
| 2 | 93.775 | Major River |
| 3 | 94.045 | Major River |
| 4 | 94.945 | Achankoil River |
| 5 | 105.691 | Pampa River |

**Table 6-13: List of Tunnels locations**

| KOLLAM TO CHENGANNUR | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 100.600 | 101.400 | 0.800 |
| **Total** | | | **0.800 Km** |

**Table 6-14: List of Viaducts locations**

| KOLLAM TO CHENGANNUR | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 63.760 | 64.480 | 0.720 |
| 2 | 65.650 | 66.400 | 0.750 |
| 3 | 66.800 | 67.940 | 1.140 |
| 4 | 68.051 | 68.231 | 0.180 |
| 5 | 69.480 | 69.720 | 0.240 |

| KOLLAM TO CHENGANNUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 6 | 70.520 | 70.790 | 0.270 |
| 7 | 72.050 | 72.200 | 0.150 |
| 8 | 72.660 | 72.930 | 0.270 |
| 9 | 78.360 | 78.600 | 0.240 |
| 10 | 80.250 | 80.430 | 0.180 |
| 11 | 80.750 | 80.960 | 0.210 |
| 12 | 91.206 | 93.756 | 2.550 |
| 13 | 93.794 | 94.000 | 0.206 |
| 14 | 94.092 | 94.572 | 0.480 |
| 15 | 99.236 | 99.386 | 0.150 |
| 16 | 100.000 | 100.240 | 0.240 |
| **Total** | | | **7.976 Km** |

**Options near Kundra Railway Station:**

The location near kundra is very critical as it crosses the Punalur Railway line and well developed habitats. Therefore near Kundara between chainages 61800 and 67700, two optional alignments have been examined to decide the best one. The two options are shown in the **Figure 6.7**. One is on the western side (left) and other one in the eastern side (right) of the Kundra Railway Staion and the west side alignment has been chosen being more economical based on the reasons given hereunder.

- The right side option has to pass through thickly populated town area, whereas the left option affects lesser numbers of buildings.
- The left side alignment is shorter than right side alignment by 400m (Right option is 5900m in length and Left option is 5500m in length).

- 


**Figure 6-7: Showing Two optional alignments for Kundara diversion**

### Options in Chengannur area:

For Chengannur Station between chainages 94500 and 105300, there are two optional alignments examined and the west (left) side alignment has been chosen being more economical and nearer to the existing Chengannur Railway Station. A sketch showing the optional alignments is furnished in the **Figure: 6.8**.

Both the optional alignments have been studied in detail and it is found that the left side alignment is better. Main pros and cons are as under;

- The right side option has to pass through thickly populated town area, whereas the left option affects lesser numbers of buildings.
- The left side alignment is shorter than right side alignment by 700m (right is 13300m in length and left is 12600m).


**Figure 6-8: Showing Two optional alignments for Chengannur diversion**

### 6.5.2.3 Section-3: Chengannur-Kottayam

Chengannur station is proposed at a distance of 4.30 Km from the existing railway station for want of suitable location near the city centre. This at-grade station is proposed near to the MC road, an important State Highway.

This station proposed at grade is provided with 2 island platforms 11.32m wide and 410m long, with 2 passenger loops and 2 main lines in between. This station is also to have 2 RORO loops.

The alignment further passes through green fields and reaches the proposed Kottayam Station at chainage 136108 near MC road at about 2.16 km from the existing Railway Station. The alignment crosses SH 10 at chainage 105366.There are 5 Cut and covers for a length of 0.630 Km, 3 Major Rivers,1 Tunnel for a length of 0.150 Km and 9 Viaducts for a Length of 3.600 Km as furnished in **Tables 6.15 to 6.18.**

**Table 6-15: Showing the locations of Cut and Covers**

| CHENGANNUR TO KOTTAYAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 120.330 | 120.475 | 0.145 |

| CHENGANNUR TO KOTTAYAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 2 | 124.150 | 124.275 | 0.125 |
| 3 | 133.150 | 133.385 | 0.235 |
| 4 | 133.950 | 134.000 | 0.050 |
| 5 | 134.150 | 134.225 | 0.075 |
| Total | | | 0.630 Km |

**Table 6-16: Showing the locations of Major Rivers Crossings**

| CHENGANNUR TO KOTTAYAM | | |
|---|---|---|
| S.No | Chainage | Name of River |
| 1 | 112.345 | Manimala River |
| 2 | 115.465 | Minor River |
| 3 | 135.473 | Kudoor River |

**Table 6-17: Showing the locations of Tunnels**

| CHENGANNUR TO KOTTAYAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 134.000 | 134.150 | 0.150 |
| | | Total | 0.150 Km |

**Table 6-18: Showing the locations of Viaducts**

| CHENGANNUR TO KOTTAYAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 1 | 116.460 | 116.700 | 0.240 |
| 2 | 117.600 | 118.170 | 0.570 |
| 3 | 119.760 | 120.060 | 0.300 |

| CHENGANNUR TO KOTTAYAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 4 | 120.550 | 120.670 | 0.120 |
| 5 | 121.050 | 121.440 | 0.390 |
| 6 | 122.050 | 122.770 | 0.720 |
| 7 | 123.450 | 124.020 | 0.570 |
| 8 | 124.550 | 125.030 | 0.480 |
| 9 | 126.150 | 126.360 | 0.210 |
| **Total** | | | **3.600 Km** |

**Options in Chegannur – Kottayam Section:**

For the approach to Kottayam Station, between chainages 114000 and 145400, there are two optional alignments examined and the west (left) side alignment has been chosen being more economical and nearer to the MC Road as well as to the existing Kottayam Railway Station. A sketch showing the optional alignments is furnished in the **Figure: 6.9.**

Main pros and cons are as under;

- It is closer to main city and near to the existing Kottayam Railway Station.
- Can be planned with flatter gradients.
- Number of affected buildings are lesser as compared to right side alignment.
- Left side option can be managed without tunnel construction whereas right side option requires a tunnel of about 550m length to cross the intervening hillocks.

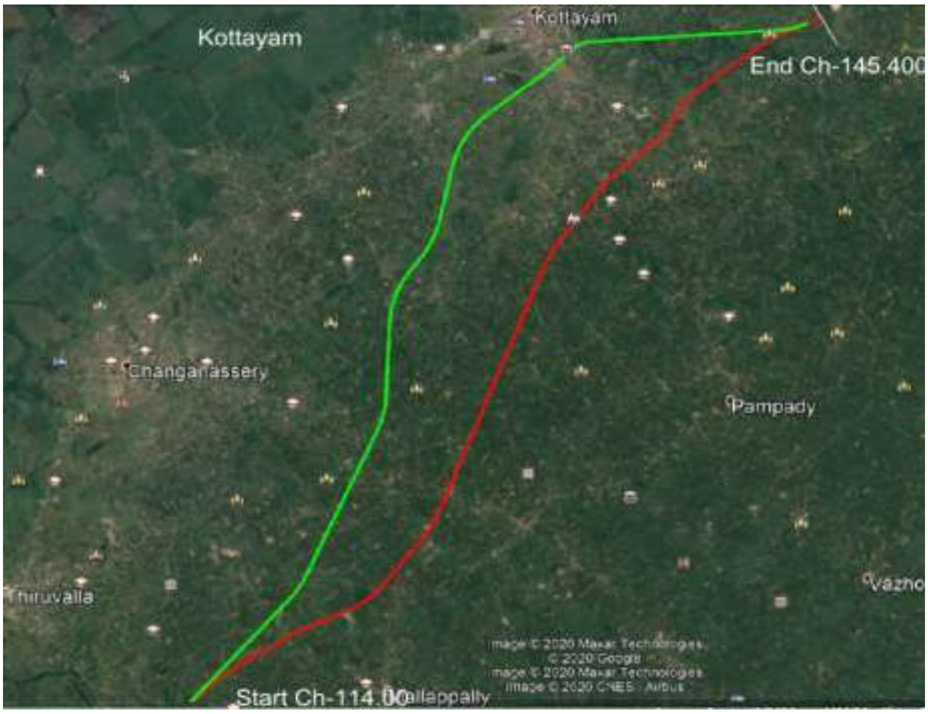



**Figure 6-9: Showing Two optional alignments towards Kottayam**

#### 6.5.2.4 Section-4: Kottayam-Ernakulam

Kottayam station isproposed at a distance of 2.16 Km from existing railway station for want of suitable locations near commercial centre and it is proposed near to the MC road, an important State Highway.

This station proposed at grade is provided with 2 nos, passenger loops with two 11.32m wide and 410m long platforms with **1** loop line on either side and 2 main lines in between. It will have 2 RORO loop lines ( 1 either side) and 1 Tourist siding with1 ballast siding on B line side.

The alignment further passes through green fields and reaches Ernakulam Station at chainage 195329 at about 10.00km from the existing Ernakulam railway station. It is kept very close to the proposed Infopark Metro station for integration with the Metro System. On the way it crosses highways at chainage 137500 (NH183A), at chainage 186800 (NH 85) and one pond at chainage 153250. It also crosses the Ernakulam to BPCL Railway siding at chainage 190175 as a rail flyover. There are 30 cut and covers for a length of 4.997 Km, 12 major rivers, 6 tunnels for a length of 2.400 Km and 26 viaducts for a Length of 14.697 Km as furnished in **Tables 6.19 to 6.22**

**Table 6-19: Showing the locations of Cut and Covers**

| KOTTAYAM TO ERNAKULAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage (Km) | Length (Km) |
| 1 | 136.725 | 136.860 | 0.135 |

| KOTTAYAM TO ERNAKULAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage (Km) | Length (Km) |
| 2 | 137.750 | 137.950 | 0.200 |
| 3 | 138.150 | 138.350 | 0.200 |
| 4 | 140.450 | 140.750 | 0.300 |
| 5 | 150.225 | 150.600 | 0.375 |
| 6 | 151.250 | 151.650 | 0.400 |
| 7 | 153.433 | 153.645 | 0.212 |
| 8 | 155.725 | 155.850 | 0.125 |
| 9 | 156.225 | 156.250 | 0.025 |
| 10 | 156.600 | 156.680 | 0.080 |
| 11 | 156.870 | 157.050 | 0.180 |
| 12 | 160.154 | 160.368 | 0.214 |
| 13 | 161.075 | 161.130 | 0.055 |
| 14 | 161.400 | 161.426 | 0.026 |
| 15 | 161.885 | 162.048 | 0.163 |
| 16 | 162.582 | 162.692 | 0.110 |
| 17 | 163.540 | 163.790 | 0.250 |
| 18 | 163.977 | 164.000 | 0.023 |
| 19 | 164.400 | 164.470 | 0.070 |
| 20 | 170.780 | 170.850 | 0.070 |
| 21 | 171.230 | 171.251 | 0.021 |
| 22 | 173.253 | 173.395 | 0.142 |
| 23 | 173.995 | 174.064 | 0.069 |
| 24 | 174.285 | 174.466 | 0.181 |

| KOTTAYAM TO ERNAKULAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage (Km) | Length (Km) |
| 25 | 179.341 | 179.455 | 0.114 |
| 26 | 179.829 | 180.237 | 0.408 |
| 27 | 180.787 | 181.075 | 0.288 |
| 28 | 182.049 | 182.233 | 0.184 |
| 29 | 182.453 | 182.610 | 0.157 |
| 30 | 183.620 | 183.840 | 0.220 |
| **Total** | | | **4.997 Km** |

**Table 6-20: Showing the locations of Major Rivers**

| KOTTAYAM TO ERNAKULAM | | |
|---|---|---|
| S.No | Chainage | Name of River |
| 1 | 138.482 | Meenachil River |
| 2 | 140.161 | Meenachil River |
| 3 | 153.341 | Major River |
| 4 | 169.476 | Moovattupuzha |
| 5 | 190.561 | Chithrapuzha |
| 6 | 190.811 | Chithrapuzha |
| 7 | 191.296 | Chithrapuzha |
| 8 | 192.176 | Chithrapuzha |
| 9 | 192.830 | Kadambrayar |
| 10 | 193.522 | Kadambrayar |
| 11 | 194.461 | Kadambrayar |
| 12 | 194.810 | Kadambrayar |

**Table 6-21: Showing the locations of Tunnels**

| KOTTAYAM TO ERNAKULAM | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 156.250 | 156.600 | 0.350 |
| 2 | 158.000 | 158.400 | 0.400 |
| 3 | 161.130 | 161.400 | 0.270 |
| 4 | 164.000 | 164.400 | 0.400 |
| 5 | 170.850 | 171.230 | 0.380 |
| 6 | 173.395 | 173.995 | 0.600 |
| **Total** | | | **2.400 Km** |

**Table 6-22: Showing the locations of Viaducts**

| KOTTAYAM TO ERNAKULAM | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 140.870 | 141.380 | 0.510 |
| 2 | 142.050 | 144.000 | 1.950 |
| 3 | 145.650 | 145.860 | 0.210 |
| 4 | 146.300 | 147.650 | 1.350 |
| 5 | 149.400 | 149.550 | 0.150 |
| 6 | 151.750 | 151.870 | 0.120 |
| 7 | 152.050 | 152.410 | 0.360 |
| 8 | 154.000 | 154.240 | 0.240 |
| 9 | 154.350 | 154.680 | 0.330 |
| 10 | 157.450 | 157.750 | 0.300 |
| 11 | 162.940 | 163.330 | 0.390 |

| KOTTAYAM TO ERNAKULAM | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 12 | 164.600 | 165.260 | 0.660 |
| 13 | 165.750 | 166.110 | 0.360 |
| 14 | 167.200 | 168.820 | 1.620 |
| 15 | 170.250 | 170.550 | 0.300 |
| 16 | 174.600 | 175.560 | 0.960 |
| 17 | 180.400 | 180.610 | 0.210 |
| 18 | 189.495 | 190.485 | 0.990 |
| 19 | 190.637 | 190.735 | 0.098 |
| 20 | 190.887 | 191.190 | 0.303 |
| 21 | 191.404 | 192.100 | 0.696 |
| 22 | 192.252 | 192.800 | 0.548 |
| 23 | 192.861 | 193.400 | 0.539 |
| 24 | 193.644 | 194.400 | 0.756 |
| 25 | 194.522 | 194.780 | 0.258 |
| 26 | 194.841 | 195.329 | 0.488 |
| **Total** | | | **14.697 Km** |

#### 6.5.2.5 Section-5: Ernakulam-Kochi Airport

Ernakulam station is proposed at a distance of 10.0 Km from the city center and commercial areas for want of space at suitable locations nearby. However, this station is proposed near the Infopark and proposed Smart City offices. There is a proposal to extend the existing Metro line to this area and the proposed Metro station is nearby. The Collectorate also is very nearby. Moreover, the proposed site is within the Corporation limits and is a very fast developing area.

This station proposed as elevated is provided with 4 island platforms 11.32m wide and 410m long, with 6 passanger loops and 2 main lines in between. This station will also have one tourist siding with 1 loop line on B side.

RORO facilities for Ernakulam is provided at chainage 199.168 with1 RORO loop line and one RORO loading line with 10m wide platform on the B line side.Further four stabling lines and one OHE maintenance depot are also provided on the A line side.

After this station, the alignment further passes through green fields and comes back to the existing railway line at chainage 211200 at about 2 km after existing Chowara Railway Station and it is running parallel up to chainage 212318 and reaches the Kochi Airport station for integration with the Cochin International Airport..

There are 5 Cut & covers for a length of 1.072 Km, 3 Major Rivers and 8 Viaducts for a length of 5.482 Km as furnished in **Tables 6.23 to 6.26.**

**Table 6-23: Showing the locations of Cut and Covers**

| ERNAKULAM TO COCHIN AIRPORT | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage (Km) | Length (Km) |
| 1 | 196.980 | 197.300 | 0.320 |
| 2 | 203.213 | 203.335 | 0.122 |
| 3 | 205.470 | 205.574 | 0.104 |
| 4 | 205.842 | 206.113 | 0.271 |
| 5 | 206.468 | 206.723 | 0.255 |
| Total | | | 1.072 Km |

**Table 6-24: Showing the locations of Major Rivers**

| ERNAKULAM TO COCHIN AIRPORT | | |
|---|---|---|
| S.No | Chainage | Name of River |
| 1 | 197.702 | Kadambrayar |
| 2 | 198.160 | Kadambrayar |
| 3 | 208.368 | Periyar River |

**Table 6-25: Showing the locations of Tunnels**

| ERNAKULAM TO COCHIN AIRPORT | | | |
|---|---|---|---|
| Sl. No | From Chainage (km) | To Chainage(km) | Length (km) |
| 1 | Nil | Nil | Nil |
| Total | | | Nil |

**Table 6-26: Showing the locations of Viaducts**

| ERNAKULAM TO COCHIN AIRPORT | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 195.329 | 195.801 | 0.472 |
| 2 | 196.350 | 196.680 | 0.330 |
| 3 | 200.380 | 200.770 | 0.390 |
| 4 | 201.850 | 202.240 | 0.390 |
| 5 | 203.750 | 203.990 | 0.240 |
| 6 | 204.400 | 205.060 | 0.660 |
| 7 | 206.790 | 208.200 | 1.410 |
| 8 | 208.536 | 210.126 | 1.590 |
| Total | | | 5.482 Km |

### 6.5.2.6 Section-6: Kochi Airport-Thrissur

Kochi Airport station is proposed close to the Airport area at grade avoiding the funnel approach area of the airport to have integration with the Cochin International Airport. In a meeting with Airport authorities and K-Rail, Airport authorities have agreed to provide feeder services and to spare necessary land for the provision of a station close to their premises.

This station will be a class-'C'(Halt) type of station with no loop lines. It is provided with two platforms 8 m wide and 410m long to cater to the airport passengers.

The alignment further runs parallel and reaches chainage 214100 near existing Angamaly Railway Station after crossing the existing railway track at chainage 214200 takes a diversion towards left side. It passes through green fields, and reaches Thrissur station at chainage 259117 to integrate with existing Thrissur Railway Station on western side at a distance of 500 m (on the southern side from the centre line of the existing station). There are 3 ROBs between 212550 and 214900 to be modified where the proposed SilverLine is running parallel to existing line for integrating with the Airport. There are 1 cut and cover for a length of 0.138 Km, 3 major rivers and 15 viaducts for a length of 20.238 Km as furnished in **Tables 6.27 to 6.30.**

**Table 6-27: Showing the locations of cut and cover**

| COCHIN AIRPORT TO THRISSUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage (Km)** | **Length (Km)** |
| 1 | 230.104 | 230.242 | 0.138 |
| | | **Total** | **0.138 Km** |

**Table 6-28: Showing the locations of Major Rivers**

| COCHIN AIRPORT TO THRISSUR | | |
|---|---|---|
| **S.No** | **Chainage** | **Name of River** |
| 1 | 222.366 | Periyar River |
| 2 | 245.630 | Minor River |
| 3 | 246.265 | Minor River |

**Table 6-29: Showing the locations of Tunnels**

| COCHIN AIRPORT TO THRISSUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (km)** | **To Chainage(km)** | **Length (km)** |
| 1 | Nil | Nil | Nil |
| | | **Total** | **Nil** |

**Table 6-30: Showing the locations of Viaducts**

| COCHIN AIRPORT TO THRISSUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 213.600 | 214.800 | 1.200 |
| 2 | 216.050 | 217.220 | 1.170 |
| 3 | 217.850 | 218.810 | 0.960 |

| COCHIN AIRPORT TO THRISSUR | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage(Km) | Length (Km) |
| 4 | 220.700 | 220.850 | 0.150 |
| 5 | 221.075 | 222.305 | 1.230 |
| 6 | 224.100 | 229.140 | 5.040 |
| 7 | 230.950 | 231.070 | 0.120 |
| 8 | 235.650 | 236.790 | 1.140 |
| 9 | 245.000 | 245.600 | 0.600 |
| 10 | 245.661 | 246.232 | 0.571 |
| 11 | 246.299 | 249.989 | 3.690 |
| 12 | 250.460 | 250.910 | 0.450 |
| 13 | 252.500 | 252.800 | 0.300 |
| 14 | 255.400 | 257.110 | 1.710 |
| 15 | 257.210 | 259.117 | 1.907 |
| Total | | | 20.238 Km |

### 6.5.2.7 Section-7: Thrissur-Tirur

Thrissur station is proposed on the western side (left side) of existing Railway Station. It is kept parallel and adjacent to the existing railway station for integration.

This station proposed as elevated is provided with 4 island platforms 11.32m wide and 410m long ( two in the begining and additional two in future) with 6 passenger loops and 2 main lines in between.

RORO facilities for Thrissur are provided at chainage 241160 in between Airport station and Thrissur station near Muriyad village. 2 RORO loops 839 m & 765 m ,1 RORO loading platform 10m wide are provided here along with 1 Engineering Maintenance depot, 1 ballast siding and 1 RRV siding as there is adequate space available here.

The section near Thrissur station is very critical. There are three ROBs existing in this section. The alignment, therefore, has to be planned over a viaduct. Existence of several

buildings on the western side of Thrissur-Punkunnam alignment makes the design of SilverLine alignment here a difficult task requiring innovative engineering solutions.

**Options at Thrissur area :-**

Two proposals have been examined for diversion of tracks to the right side, one by shifting one existing track and another by shifting both existing tracks..

The second proposed site plans marked in google map are shown in Fig: 6.10 & 6.11.

In proposal 1 the existing railway lines are to be shifted towards eastern sides and silver line are to be provided on the western side. However, this option was not favoured by the railway authorities.

It is planned in proposal 2 to shift both the existing railway main lines towards eastern side creating space for the future 3rd and 4th line of the railways. The silver line viaduct will be over the existing railway down line. This alignment will be running in between the shifted main line and the alignment of the future 3rd and 4th lines up to Punkunnam station.Rail flyover crossings over the existing mainlines are acordingly avoided.

The alignment beyond Punkunnam crosses Thrissur-Guruvayur line at chainage 262900 and takes a diversion to Tirur through greenfields.


**Figure 6-10: Cut and Connection location at CH: 260400**


**Figure 6-11: Cut and Connection location at CH:262150**

After through discussions, Southern Railway representatives and K-Rail team came to a conclusion that shifting the two existing railway tracks between chainage 260400 and chainage 262150 towards eastern side (right side) suitably by a distance of 7.8m and 13.10m duly cutting and & connecting existing tracks taking advantage of existing curves at Thrissur and Punkunnam ends would be the best course of action to avoid the high level disturbance to local public and train running in the existing lines. The SilverLine tracks will be on a viaduct structure in this length.

A cross-section showing final proposals is shown in Figure 6.12.

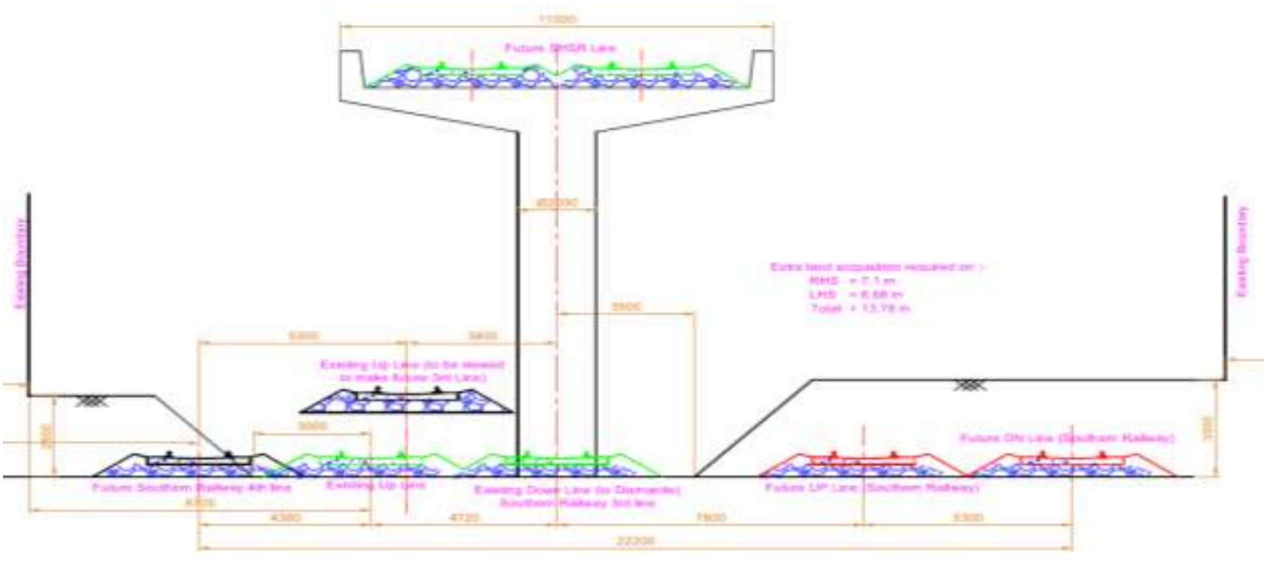


**Figure 6-12: Typical cross section showing existing tracks, SilverLine tracks and the proposed3rd and 4th lines of Southern Railway**

The diversion from Punkunnam to Tirur passes through greenfields and comes close to the railway track at chainage 310100, it runs parallel and adjacent to existing track and reaches Tirur at chainage 320562 at a distance of 3.82 km from the existing Railway Station on Kasaragod side.

There are 3 ROBs between Thrissur to Punkunnam to be modified. There are 12 Cut & covers for a length of 2.391 Km, 4 major rivers and 12 Viaducts for a Length of 10.723 Km, as furnished in Tables 6.31 to 6.34.

**Table 6-31: Showing the locations of Cut and Covers**

| THRISSUR TO TIRUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage (Km)** | **Length (Km)** |
| 1 | 282.050 | 282.170 | 0.120 |
| 2 | 283.970 | 284.105 | 0.135 |
| 3 | 284.860 | 285.074 | 0.214 |
| 4 | 286.717 | 287.182 | 0.465 |
| 5 | 288.034 | 288.300 | 0.266 |
| 6 | 289.021 | 289.122 | 0.101 |
| 7 | 290.687 | 290.749 | 0.062 |
| 8 | 293.150 | 293.370 | 0.220 |
| 9 | 294.865 | 294.977 | 0.112 |
| 10 | 300.840 | 301.081 | 0.241 |
| 11 | 302.500 | 302.640 | 0.140 |
| 12 | 303.366 | 303.681 | 0.315 |
| **Total** | | | **2.391 Km** |

**Table 6-32: Showing the locations of Major Rivers**

| THRISSUR TO TIRUR | | |
|---|---|---|
| **S.No** | **Chainage** | **Name of River** |
| 1 | 263.585 | Canal |
| 2 | 307.155 | Bharathapuzha River |
| 3 | 313.785 | Ponnani River |
| 4 | 317.065 | Ponnani River |

**Table 6-33: Showing the location of Tunnel**

| THRISSUR TO TIRUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (km)** | **To Chainage(km)** | **Length (km)** |
| 1 | Nil | Nil | Nil |
| | | **Total** | **Nil** |

**Table 6-34: Showing the locations of Viaducts**

| THRISSUR TO TIRUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 259.117 | 263.570 | 4.453 |
| 2 | 263.600 | 264.050 | 0.450 |
| 3 | 265.040 | 266.000 | 0.960 |
| 4 | 272.450 | 272.900 | 0.450 |
| 5 | 274.470 | 274.650 | 0.180 |
| 6 | 275.270 | 275.600 | 0.330 |
| 7 | 276.400 | 276.700 | 0.300 |
| 8 | 285.200 | 285.710 | 0.510 |
| 9 | 288.350 | 288.890 | 0.540 |

| THRISSUR TO TIRUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 10 | 294.153 | 294.573 | 0.420 |
| 11 | 301.250 | 302.240 | 0.990 |
| 12 | 308.000 | 309.140 | 1.140 |
| **Total** | | | **10.723 Km** |

### 6.5.2.8 Section-8: Tirur-Kozhikode

Tirur station is proposed on the left-hand side of the existing railway line as we go towards Kasaragod. It is parallel and adjacent to the existing railway line at a distance of 3.82 Km from existing Railway Station due to space constraints near to the existing railway station on the northern side.

This station proposed at grade is provided with 2 Island platforms 11.32m wide and 410m long with 2 loop lines and 2 mainlins in between. 2 RORO loops are also proposed on the Northern side beyond the top point. 1 OHE depot is also proposed here.

Alignment after Tirur station further runs parallel and adjacent to the existing railway lines on their left side observing the SilverLine parameters up to chainage 357868 and reaches existing Kozhikode Railway Station. The alignment from Tirur to kasaragod is planned to be parallel and by the side of existing railway lines to use existing railway land and reduce new land acquisition as much as possible, however by strictly following the SilverLine design norms to avoid introduction of unnecessary speed restrictions. At some locations, however, small deviations from existing rail lines are unavoidable as otherwise crippling speed restrictions would become necessary reducing the average speed of the section.

The new tracks of SilverLine will be laid at a minimum distance of 7.8m between the center lines of adjoining tracks of the existing railway line and SilverLine.

The alignment at Kozhikode has been considered in UG due to site constraints like heavily built up areas, river, etc and also to reduce the costlier land & property acquisition as discussed hereunder.

**Underground proposal at Kozhikode**

Kozhikode is one of the major cities of the State. It has been appropriate to connect the existing Railway station of Kozhikode with Silver Line by providing the station close to the existing one. The Kozhikode city is thickly populated along the existing railway lines as shown in some of the following site pictures. Cost of the land and properties is very high in the area.

Following are the main considerations in preferring an underground arrangement over at-grade and elevated proposals.

1) Alignment has to pass through thickly populated area of the Kozhikode city and land and property acquisition for an at grade station and approaches will be very costly.
2) There may be serious opposition for the project in view of large number of properties acquisition, which may delay the project far too long.
3) Even if the alignment is planned over viaducts, there will be need to plan the alignment with tall viaducts because of the following major crossings;
    a. Major River (Kallayi) Crossing at chainage 356.500.
    b. 4 nos. existing ROB’s at chainages355.500 , 358.000, 358.900, 359.800.
    c. One RUB at Chainage 357.200.
    d. 2 nos. IR Level Crossings at chainages 359.300 and 360.250 requiring new ROBs.

- Reconstruction of these ROB's across busy roads and new construction will also require large scale acquition of land and buildings in the built-up area.


**Figure 6-13: Kozhikode city with its congested streets**

Hence it is planned to have the alignment and the station in Underground.

Pros and cons of the under ground alignment are listed below;

**Pros:**

a. It will avoid the cost of one major river bridge, modification to existing 4ROBs and 1 RUB and two new ROB construction.
b. Saving of land and property acquisition for 15m width for about 7Km except ramp portions at the ends of tunnel.
c. 520 Nos of properties will be saved approximately.
d. Least disturbance to public during construction and their properties.
e. No need of traffic diversions and traffic management during construction for this major length of about 7Km.
f. No public resistance likely for the implementation of the project in view of its advantages.
g. Smooth and steady construction
h. No additional requirement of temporary land for machinery and materials.
i. Station can be constructed in railway land by cut and cover method with due integration. After that the land can be used for circulation, park, public parking and other commercial uses.
j. UG station concourse floors can be used for developing common facilities for Southern Railway and SilverLine.

**Cons:**

a. It will require highly skilled design team to provide a safe tunnel as it will be close to the Sea and will have to cross the Kallayi river.
b. It will require high class construction and supervision during construction of tunnel preferably by using TBM of required category and standards.

Existing ROBs, RUB, LCs and River locations are shown below in **Figures 6.14 to 6.21** which show the difficulties involved in construction in the area.


**Figure 6-14: ROB Chainage 355+500**


Figure 6-15: Kallayi River at Chainage 356+500


Figure 6-16: RUB Chainage 357+200

**Figure 6-17: ROB Chainage  358+000**

**Figure 6-18: ROB Chainage 358+950**


Figure 6-19: Existing LC's Chainage 359+300


Figure 6-20: ROB Chainage 359+800


Figure 6-21: Existing LC's Chainage 360+250


Figure 6-22: Kozhikode Railway Station and Parking Area

In view of the above pros and cons and careful consideration, at this stage underground proposal is recommended. It can be reviewed during construction stage after more detailed geological data is available.

**Features of alignment in Kozhikode area (UG) :-**

Alignment design in this stretch in underground is done on the basis of tentative considerations of the safe cushion depth above and in the sides of the tunnels required to decide the depth of the tunnels as per site constraints and obligatory points.

- About 7.9 Km will be the underground alignment at Kozhikode which includes 5.214 km of full depth horizontal tunnel (appx.2.292Km in north (Kasaragod side) and 2.922Km in south (Tirur side)).
- **Kallayi river crossing**
  Rail level has been designed with double of the tunnel diameters cushion i.e. about 12m. Accordingly the rail level is kept at 18m from the bed level of the River. This will have to reviewed after detailed hydrological and geotechnical studies before execution. Due to high depth of the alignment requirement at this river location in close vicinity of the Kozhikode station, the depth of the rail level at proposed Kozhikode station comes to 33.621m. This will be updated during execution as per actual requirement of the rail level for river crossing.
- **Existing ROBs crossings**
  Alignment has been designed in such a way that it does not affect the existing ROBs. A safe clear distance of minimum 3m is considered from the bottom of the piles of the Southern Railway bridges. At some of the locations due to short spans of ROBs, we may require single tracked tunnels to avoid modifications of the existing ROBs.
- **Crossing under existing structures**
  Alignment has been designed in such a way that it passes through low depth foundations of structures and not under the high rise buildings with pile foundations. Accordingly the rail level is kept at minimum 21m depth from the ground level assuming about 18m cushion depth under the foundation of the existing buildings. Building condition survey will be required during execution as per standard practice. This also has to be reviewed as per building condition survey and the data from detailed geotechnical investigations before execution.

Further in the Tirur – Kozhikode alignment, there are 18 ROBs which require to be modified. There are 1cut & cover length of 0.746 Km, 4 major rivers and 1 tunnel for a length of 2.922 Km as furnished in **Tables 6.35 to 6.37.**

**Table 6-35: Showing the locations of Cut and Cover**

| TIRUR TO KOZHIKODE | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage (Km) | Length (Km) |
| 1 | 354.200 | 354.946 | 0.746 |
| Total | | | **0.746 Km** |

**Table 6-36: Showing the locations of Major Rivers**

| TIRUR TO KOZHIKODE | | |
|---|---|---|
| **S.No** | **Chainage** | **Name of River** |
| 1 | 329.356 | Poorapuzha |
| 2 | 342.508 | Kadalundi River |
| 3 | 346.005 | Chaliayar River |
| 4 | 348.467 | Feroke River |

**Table 6-37: Showing the locations of Tunnels**

| TIRUR TO KOZHIKODE | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (km)** | **To Chainage(km)** | **Length (km)** |
| 1 | 354.946 | 357.868 | 2.922 |
| | | **Total** | **2.922 Km** |

**Table 6-38: Showing the locations of Tunnels**

| TIRUR TO KOZHIKODE | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | Nil | Nil | Nil |
| **Total** | | | **Nil** |

### 6.5.2.9 Section-9: Kozhikode-Kannur

Kozhikode station is proposed on the left-hand side, parallel and adjacent to the existing railway station for integration with existing railway station.

This station proposed underground is provided with 2 island platforms 11.32m wide and 410m long, with 2 passengers loop lines and 2 main lines in between. Station's amenities will be developed at ground level.

2 RORO loops are provided at a different location at existing West Hill Railway Station. 3 stabling lines and1 ballast siding are also proposed here.

The alignment further runs parallel and adjacent to the existing tracks duly observing SilverLine parameters and crosses the existing track at chainage 405031 by a

Rail flyover, that is about 2Km north of existing Thikkoti Railway Station. It further runs parallel and adjacent to existing up line on right hand side up to chainage 406262 and crosses the existing track by another Rail flyover and then alignment further runs parallel of the left side up to chainage 420874 and crosses the existing track as a Rail flyover again. It further runs up to chainage 420972 and crosses the existing Railway line and runs parallel up to chainage 427170 and crosses the existing Railway lines as a Rail flyover and runs on the right side of the existing Railway line and reaches the Kannur SilverLine station at chainage 446095 opposite to the existing Kannur Railway Station for integration with the existing Southern Railway Kannur Station.

There are 31 ROBs to be modified in the section. The alignment also crosses NH 17 at nine locations at chainages 366680, 370100, 379250, 388522, 407731, 420746, 425170, 432850,433000, State highways at chainage 414340 and major district roads at 13 places at chainages 363150, 371680, 374010, 381200, 381530, 383700, 384410, 404600, 424700, 441335, 441895, 444815, 445495 and 439400.

There are 4Cut & covers for a length of 1.318 Km, 4 Major Rivers, 1 Tunnel for a length of 2.292Km apart from approaches in cut and covers and 10 Viaducts for a Length of 13.507 Km as furnished in **Tables 6.38 to 6.41**

**Table 6-389: Showing the locations of Cut and Covers**

| KOZHIKODE TO KANNUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage (Km)** | **Length (Km)** |
| 1 | 360.160 | 360.870 | 0.710 |
| 2 | 410.400 | 410.600 | 0.200 |
| 3 | 419.031 | 419.248 | 0.217 |
| 4 | 426.696 | 426.887 | 0.191 |
| **Total** | | | **1.318 Km** |

**Table 6-4039: Showing the locations of Major Rivers**

| KOZHIKODE TO KANNUR | | |
|---|---|---|
| **S.No** | **Chainage** | **Name of River** |
| 1 | 370.720 | Korapuzha River |
| 2 | 399.959 | Major River |
| 3 | 417.277 | Mayyazhi River |
| 4 | 427.202 | Kayyali River |

| KOZHIKODE TO KANNUR | | |
|---|---|---|
| **S.No** | **Chainage** | **Name of River** |
| 5 | 428.263 | Dharmadam River |
| 6 | 430.283 | Anjarakandy River |

**Table 6-41: Showing the locations of Tunnels**

| KOZHIKODE TO KANNUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (km)** | **To Chainage(km)** | **Length (km)** |
| 1 | 357.868 | 360.160 | 2.292 |
| | | **Total** | **2.292 Km** |

**Table 6-42: Showing the locations of Viaducts**

| KOZHIKODE TO KANNUR | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 368.790 | 370.620 | 1.830 |
| 2 | 370.820 | 372.200 | 1.380 |
| 3 | 403.585 | 404.972 | 1.387 |
| 4 | 406.000 | 407.320 | 1.320 |
| 5 | 420.220 | 422.620 | 2.400 |
| 6 | 424.719 | 426.249 | 1.530 |
| 7 | 437.022 | 437.322 | 0.300 |
| 8 | 438.083 | 438.263 | 0.180 |
| 9 | 440.015 | 442.835 | 2.820 |
| 10 | 445.310 | 445.670 | 0.360 |
| **Total** | | | **13.507 Km** |

**Option studied in Kozhikode –Kannur Section:**

For Kozhikode–Kannur Section between chainages 383000 and 439500, there have been two optional alignments examined and the west (left) side alignment has been

chosen being more economical/ desirable due to being nearer to the existing Railway lines for more length. A sketch showing the optional alignments is furnished in the **Figure: 6.23**.

Both the optional alignments have been studied in detail and it is ultimately decided that the left side alignment is better. Main pros and cons are as under;

- The right side option has to pass through a long populated town area, whereas the left option affects lesser numbers of buildings. Because at a few locations it has open areas too.
- Left side alignment uses the railway land to the maximum extent.
- The left side alignment is shorter then right side alignment by 1165m.
- The drawback of left side alignment is that it entrapped the land parcels between existing railway lines and SilverLine alignment at 13 locations and has to pass through thickly populated area of Vadakara and Thalasseri towns.


**Figure 6-23: Showing Two optional alignments towards Kanur**

### 6.5.2.10 Section-10: Kannur-Kasaragod :-

Kannur station is proposed opposite to the existing Kannur Railway Station on the right hand side very close and parallel to the existing railway lines for integration with the existing railway station.

This station proposed at grade is provided with 2 island platforms 11.32m wide 410m long, with 2 passengers loops and 2 main lines in between. At a separate location close to Kannur at chainage 447459, 2 passanger stabling lines are proposed for want of space at Kannur station. 2 Nos RORO loops,1 OHE Maintenance depot and 1 Engineering depot with a rail level platform along with additional laybyes are also provided here.

The alignment further runs parallel and adjacent to the existing track duly observing SilverLine parameters and crosses the existing tracks at chainage 521835 at 1.4 Km north of existing Kottikkulam Railway Station and further runs parallel and adjacent to the existing Down line on the left hand side and reaches Kasaragod station at chainage 529450 opposite to existing Kasaragod Railway Station for integration with existing Southern Railway.

There are also 9 ROBs to be modified in the section. The alignment also crosses NH 17 at 4 locations at chainages 496035, 500935, 516535 and 52835 and crosses the proposed bypass of NH-17 at CH:414235 and CH: 417535.

The alignment passes through RORO stations of Kannur at chainage 447459,

There are 13 Cut & covers for a length of 2.384 Km, 13 Major rivers, 1 Tunnels for a length of 1.964 Km and 2 Viaduct for a length of 0.930 Km as furnished in **Tables 6.42 to 6.45.**

**Table 6-403: Showing the locations of Cut and Covers**

| KANNUR TO KASARAGOD | | | |
|---|---|---|---|
| Sl. No | From Chainage (Km) | To Chainage (Km) | Length (Km) |
| 1 | 450.870 | 451.180 | 0.310 |
| 2 | 462.516 | 462.655 | 0.139 |
| 3 | 467.686 | 467.796 | 0.110 |
| 4 | 469.760 | 469.780 | 0.020 |
| 5 | 470.839 | 470.978 | 0.139 |
| 6 | 517.800 | 518.107 | 0.307 |
| 7 | 521.640 | 521.965 | 0.325 |
| 8 | 522.400 | 522.600 | 0.200 |
| 9 | 523.447 | 523.535 | 0.088 |
| 10 | 524.029 | 524.360 | 0.331 |

| KANNUR TO KASARAGOD | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage (Km)** | **Length (Km)** |
| 11 | 525.384 | 525.564 | 0.180 |
| 12 | 528.107 | 528.194 | 0.087 |
| 13 | 528.654 | 528.802 | 0.148 |
| **Total** | | | **2.384 Km** |

**Table 6-414: Showing the locations of Major Rivers**

| KANNUR TO KASARAGOD | | |
|---|---|---|
| **S.No** | **Chainage** | **Name of River** |
| 1 | 453.133 | Vallapatanam River |
| 2 | 466.994 | Kuppam River |
| 3 | 470.611 | Vayalapram River |
| 4 | 474.690 | Perumba River |
| 5 | 479.569 | Major River |
| 6 | 494.210 | Minor River |
| 7 | 495.277 | Major River |
| 8 | 499.845 | Karingodu River |
| 9 | 513.110 | Chithari River |
| 10 | 518.341 | Major River |
| 11 | 523.780 | Major River |
| 12 | 526.780 | Chandragiri River |
| 13 | 527.563 | Major River |

**Table 6-425: Showing the locations of Tunnels**

| KANNUR TO KASARAGOD | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (km)** | **To Chainage(km)** | **Length (km)** |
| 1 | 467.796 | 469.760 | 1.964 |
| **Total** | | | **1.964 Km** |

**Table 6-436: Showing the locations of Viaducts**

| KANNUR TO KASARAGOD | | | |
|---|---|---|---|
| **Sl. No** | **From Chainage (Km)** | **To Chainage(Km)** | **Length (Km)** |
| 1 | 518.535 | 519.015 | 0.480 |
| 2 | 524.585 | 525.035 | 0.450 |
| **Total** | | | **0.930 Km** |

#### 6.5.2.11 Section-11: Kasaragod to Kasaragod Depot.

The Kasaragod station is proposed on the western side of the existing railway station parallel to the same for integration with the existing Kasaragod Railway Station. One Depot at about 3 Km on the Mangalore side of the Kasaragod station is planned where there is adequate private land available for acquisition at a comparatively lesser cost.

This station proposed at grade is provided with 4 island platforms 11.32m wide & 410m long, with 6 passengers loops and 2 main lines in between being a terminal station.1 Tourist siding on B side is also provided at this station.

Kasaragod depot is provided at about 3 Km from main station and the yard top point is at about 1.635 Km from Kasaragod station center at that end. 4 IBLs 410m, 1 P. Way siding,1 BD Special,1 ARME line, 1 Test Track 1092 m, 15 Stabling lines, 2 RORO loops and 1 RORO loading siding with 10m wide platform and one RRV siding are proposed at the Depot location.

The alignment after Kasaragod station further runs parallel to the existing Southern Railway tracks up to chainage 531085 as shown in the alignment plans for a length of about 1.635 Km and connects the proposed Kasaragod Depot.

#### 6.5.2.12 Yard plans

Yard plans of all stations proposed in the alignment are given in the Chapter 8: Civil Engineering of this DPR.

### 6.5.2.13 Details of Route length

Details of Route length, total length and Station locations and other facilities are shown below in Table 6-46.

**Table 6-44: Showing the route length and proposed station locations**

| Sl.No. | Station Name | Chainage in (Km) | Inter distance in (Km) | Latitude (N) | Longitude( E) |
|---|---|---|---|---|---|
| **1** | Begining of Track / Dead End | -1.100 | 0.000 | | |
| **2** | Thiruvananthapuram | 0.000 | 1.100 | 8°30'44.94"N | 76°53'50.63"E |
| **3** | Kollam | 55.338 | 55.338 | 8°53'44.51"N | 76°39'25.56"E |
| **4** | Chengannur | 102.900 | 47.562 | 9°18'28.66"N | 76°38'26.37"E |
| **5** | Kottayam | 136.108 | 33.208 | 9°34'33.43"N | 76°22'18.74"E |
| **6** | Ernakulam | 195.329 | 59.221 | 10° 0'48.99"N | 76°22'36.56"E |
| **7** | Kochi Airport | 212.318 | 16.989 | 10° 9'21.98"N | 76°22'51.02"E |
| **8** | Thrissur | 259.117 | 46.799 | 10°30'31.32"N | 76°12'19.67"E |
| **9** | Tirur | 320.562 | 61.445 | 10°56'46.40"N | 75°54'08.66"E |
| **10** | Kozhikode | 357.868 | 37.306 | 11°14'49.70"N | 75°46'46.89"E |
| **11** | Kannur | 446.095 | 89.392 | 11°52'19.04"N | 75°22'08.96"E |
| **12** | Kasaragod | 529.450 | 83.355 | 12°29'27.51"N | 74°59'13.30"E |
| **13** | Kasaragod Depot Entry chainage(End Of Main Line) | 531.085 | 1.635 | | |
| **14** | **Total Length Start to End (Km)** | | **532.185** | | |
| **15** | **Total Length Thiruvananthapuram station Center to Kasaragod station Center** | | **529.450** | | |
| | **Depot Locations** | | | | |
| **1** | **Kollam** | **55.338** | **0.000** | **8°53'03.23"N** | **76°38'53.47"E** |
| **2** | **Kasaragod** | **530.953** | **475.615** | **12°30'45.59"N** | **74°58'21.03"E** |
| | **RORO Loding/Unloading Points** | | | | |
| **1** | **Thiruvananthapuram RORO(At Kazhakkoottam)** | **8.019** | **0.000** | **8°34'27.49"N** | **76°51'53.64"E** |
| **2** | **Kollam( Attached to station)** | **55.338** | **47.319** | **8°53'44.51"N** | **76°39'25.56"E** |
| **3** | **Ernakulam RORO (At Pazhanganad)** | **199.168** | **143.830** | **10° 2'42.63"N** | **76°23'25.42"E** |
| **4** | **Thrissur RORO(At Muriyad)** | **241.160** | **41.992** | **10°22'2.96"N** | **76°15'00.27"E** |

| Sl.No. | Station Name | Chainage in (Km) | Inter distance in (Km) | Latitude (N) | Longitude( E) |
|---|---|---|---|---|---|
| 5 | Kasargod RORO (At Kasaragod Depot) | 531.950 | 290.790 | 12°30'33.22"N | 74°58'28.92"E |
| Independent RORO Without Loading/Unloading Points | | | | | |
| 1 | Kozhikode RORO (At West Hill) | 362.471 | 0.000 | 11°17'9.55"N | 75°45'52.78"E |
| 2 | Kannur RORO(Near Kannur) | 447.459 | 84.988 | 11°53'1.25"N | 75°21'45.63"E |
| Engineering Maintanace Depot | | | | | |
| 1 | Kollam(attached to station) | 55.338 | 0.000 | 8°53'44.51"N | 76°39'25.56"E |
| 2 | Thrissur RORO (At Muriyad) | 241.160 | 185.822 | 10°22'2.96"N | 76°15'00.27"E |
| 3 | Kannur RORO(Near Kannur) | 447.459 | 206.299 | 11°53'1.25"N | 75°21'45.63"E |
| OHE Maintenance Depot | | | | | |
| 1 | Kollam | 55.338 | 0.000 | 8°53'44.51"N | 76°39'25.56"E |
| 2 | Ernakulam RORO (At Pazhanganad) | 199.168 | 143.830 | 10° 2'42.63"N | 76°23'25.42"E |
| 3 | Tirur | 320.562 | 121.394 | 10°56'46.40"N | 75°54'08.66"E |
| 4 | Kannur RORO(Near Kannur) | 447.459 | 126.897 | 11°53'1.25"N | 75°21'45.63"E |
| Ballast Depot Location | | | | | |
| 1 | Kollam (Attached to station) | 55.338 | 0.000 | 8°53'44.51"N | 76°39'25.56"E |
| 2 | Kottayam( Attached to station) | 136.108 | 80.770 | 9°34'33.43"N | 76°32'18.74"E |
| 3 | Thrissur RORO (At Muriyad) | 241.160 | 105.052 | 10°22'2.96"N | 76°15'00.27"E |
| 4 | Kozhikode RORO (At West Hill) | 362.471 | 121.311 | 11°17'9.55"N | 75°45'52.78"E |
| Brake Down Special Sidings | | | | | |
| 1 | Kollam Depot | 55.338 | 0.000 | 8°53'03.23"N | 76°38'53.47"E |
| 2 | Kasaragod Depot | 530.953 | 475.615 | 12°30'45.59"N | 74°58'21.03"E |
| RRV Siding Locations | | | | | |

| Sl.No. | Station Name | Chainage in (Km) | Inter distance in (Km) | Latitude (N) | Longitude( E) |
|---|---|---|---|---|---|
| 1 | Kollam Depot | 55.338 | 0.000 | 8°53'03.23"N | 76°38'53.47"E |
| 2 | Thrissur RORO( At Muriyad) | 241.160 | 185.822 | 10°22'2.96"N | 76°15'00.27"E |
| 3 | Kasaragod Depot | 530.953 | 289.793 | 12°30'45.59"N | 74°58'21.03"E |

## 6.6 IMPORTANT DETAILS OF SILVERLINE PROJECT

### 6.6.1 Lengths of various types of structures

The details of length of Tunnels, Viaduct, Embankments, Cuttings, Cut & Cover and bridges over entire length of 532.185 Kms right up to the Kasaragod depot entry from Thiruvananthapuram are given hereunder in **Table 6.47**.

**Table 6-45: Abstract of Alignment details**

| Type of structures | Length (%age of route length) |
|---|---|
| Tunnels | 11.528 Km (2.17%) |
| Bridges | 12.991 Km (2.44%) |
| Viaducts | 88.412Km (16.61%) |
| Embankments | 292.728 Km (55.00%) |
| Cuttings | 101.789 Km (19.12%) |
| Cut & cover | 24.789Km (4.66%) |
| Total Length | 532.185 (100%) |

### 6.6.2 Religious Structures encountered along the proposed alignment

In-spite of all the efforts to avoid the religious structures on the SilverLine, still 9 structures (3Temples,1 Church and 5 Masjids) are infringing the proposed alignment. Efforts will be made to shift these during execution. Necessary action is required to be taken before the execution of the project. The details of these structures are given in **Table No 6.47 to 6.49** below.

**Table 6-46: Details of Religious structures (Temples)**

| Sl No | Location | Name of Temple | Photograph | Remarks |
|---|---|---|---|---|
| 1 | 7+700 | Sree Ujjayini Mahakali Amman Temple |  | Cannot be saved<br><br>Adjacent to track |
| 2 | 451+180 | Arpanthod Sree Arayalthara Muthappan Kavu |  | Cannot be saved<br><br>Adjacent to track |
| 3 | 496+515 | Sree Subrahmanyan Kovil, Pallikkara, Nileshwa |  | Cannot save<br><br>Adjacent to track |

**Table 6-47: Details of Religious structures (Churches)**

| Sl. No | Location | Name of Church | Photograph | Remarks |
|---|---|---|---|---|
| 4 | 6+510 | The Pentecostal Mission Church |  | Cannot save<br><br>Adjacent to track |

**Table 6-48: Details of Religious structures (Masjids)**

| Sl. No | Location | Name of Masjid | Photograph | Remarks |
|---|---|---|---|---|
| 5 | 10+030 | Town Masjid – Mosque, Kaniyapuram | Photograph not available | Cannot save<br>Adjacent to track |
| 6 | 312+150 | Vengaloor Sunni Juma Masjid - Talakkad, |  | Cannot save<br>Adjacent to track |
| | 312+175 | Vengaloor Sunni Juma Masjid - 3365 |  | |
| 7 | 366+710 | Masjid - Mosque<br>Vengali Pavangad, | Photograph not available | Cannot save<br>Adjacent to track |
| 8 | 444+375 | Aanayidukku Juma Masjid. |  | Cannot save<br>Adjacent to track |
| 9 | 529+035 | Islamiyah<br>Mazjid | Photograph not available | Kasaragod Station Area |

### 6.6.3 Alignment Crossing the existing roads

It has been the basic principle of the alignment design for the project that adopted alignment is economical and safe. Accordingly, it has been the choice of the alignment design team to keep the height of the formation as minimum as possible subject to at least 1m above the High Flood Level of the area.

Accordingly, at the minor urban road's low height (3.6m clearance) subways are considered. For highways and major urban roads (5.5m clearance) subways/ bridges are considered. Wherever feasible, the road locations have been crossed through RUBs to minimise the height of bank / viaducts or depth of cuttings.

### 6.6.4 Provision for Connectivity with other Systems

- **Connectivity with Existing Airport at Thiruvananthapuram**

The proposal to have an airport station close to the International airport at Thiruvananthapuram at chainage (-) 4300 to serve the Airport commuters will be taken up in future only. Connectivity to Thiruvananthapuram airport is not considered viable due to less traffic, though the feasibility has been worked out.

- **Connectivity with existing Airport at Kochi**

Kochi Airport station is proposed close to the Airport area at grade avoiding the funnel area of the airport to have integration with Cochin International Airport. In a meeting with Airport authorities and K-Rail, Airport authorities have agreed to provide feeder services and to spare necessary land for the provision of a station close to their premises.

- **Connectivity with existing Airports at Kozhikode and Kannur**

These two airports are far away from the alignment and hence no proposal has been studied to connect these airports presently.

- **Connectivity with Metro and LRTS projects**

Passenger integration of Kochi Metro Phase II station at Kakkanad (Info park area) has been planned with the Ernakulum station of SilverLine.

The proposed LRTS is connecting the existing Kozhikode railway station on right hand side of the station entry and the proposed SilverLine station is on the left hand side. To integrate with existing station with SilverLine through existing railway station and LRTS station platforms,a subway and escalator arrangement can be planned during construction.

Two google maps showing the Kochi metro Infopark station of 3$^{rd}$ phase integration and LRTS integration at Kozhikode are placed as **Figure 6.24**.



**Figure 6-24: Ernakulum & Kozhikode Metro and LRT  Intigration With Silver Line**

## 6.7 OTHER CRITICAL STRETCHES

Apart from the critical stretches mentioned in para 6.5 in detail, a few other critical locations will need extra care and complete pre arrangements before execution is taken up to avoid catestropic accidents or serious disturbances to the surrounding locations. Approval from all concerned authorities for crossing the NH, SH. MDRs, Rivers and Railway lines etc are to be obtained before execution. All the tunnel constructions are to be designed with detailed geological conditions with prime safety and desired quality. All the stretches near by the rivers, low lying valleys and other water bodies are also critical

locations. Construction of the viaducts or bridges to pass through these areas will require extra care and skill to make them safe during and after construction.

1. NH 544 crossing at four locations at chainages 28532,44800,48538 and 50460 between Thiruvananthapuram- Kollam section.
2. Tunnel construction between chainages 33700-34000, 34850-35350, 40200-40400,100600-101400,134000-134150,156250-156600,158000-158400,161130-161400,164000 -164400, 170850-171230, 173395-173995, 354946-360160 and 467796 – 469760 between Thiruvananthapuram to Kasorgod section ( Total 11.528 Km).
3. Railway line crossings construction in Cut & Covers between chainages 62970-63580 & 521640-521965 for Kollam-Punalur railway line and Shornur – Mangalore line crossing at chainages 63100 near Kundara and 521835 near Kasaragod respectively.
4. Railway line crossings construction as Rail Over Rail (ROR) at Chainages 190175 Ernakulum BPCL Line, 214200 Ernakulum SRR Line, 262900 Thrissur- Gurvayoor line and 405031, 406262, 420874, 421973 and 427170 crossing as Rail flyovers between Kozhikode and Kanur Mangalore to Shornur line.
5. The Kollam station area falls mainly in paddy fields with low lying areas. Its RL has been decided on the basis of general HFL of the area. It is required to be reviewed critically during execution so that the construction of SilverLine station and Depot does not affect the area adversely and the SilverLine construction is safe and workable in the high floods.
6. Kollam- Madurai Highway 183A crossing at chainage 77050 in Kollam-Chengannur section.
7. MC Road crossing at chainage 102050 in Kollam-Chengannur section.
8. SH 10 Road crossing at chainage 105366 in Chengannur and Kottayam section.
9. SH 16 Road crossing at chainage 204100 between Ernakulam and Kochi Airport section.
10. Three ROBs modification between Kochi Airport & Angamaly railway stations.
11. Construction of viaduct between Thrissur and Punkunnam railway stations duly diverting the existing Up & Down lines.
12. Crossing of three ROBs between Thrissur and Punkunnam stations.
13. Construction of ROBs for SH 76 & 50 & NH 17 at chainages 283450,291525 and 298050 respectively and road crossings at chainage 275970 between Thrissur and Tirur stations.

## 6.8 GENERAL ALIGNMENT FEATURES OF SilverLine

### 6.8.1 Horizontal Alignment Features

A full list of 201 horizontal curves showing the total length, transition length, start of the curve , end of the curve, etc. is given in **Table No 6.51** below. Summary is also included in the **Table. 6.51**.Similarly, gradients with vertical curve details are given in **Table 6.52.**

**Table 6-49: Horizontal Curve Details**

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 1 | C1 | 400 | -831.109 | -618.796 | 212.313 | 2x50=100 | RH | TVA - TVM | On Shunting Neck ML |
| 2 | C2 | 3000 | 927.137 | 1272.755 | 345.618 | 2x130=260 | LH | TVM - KLM | |
| 3 | C3 | 3000 | 1460.718 | 2655.252 | 1194.534 | 2x130=260 | RH | TVM - KLM | |
| 4 | C4 | 1850 | 3969.974 | 4865.966 | 895.992 | 2x180=360 | RH | TVM - KLM | |
| 5 | C5 | 4000 | 5018.709 | 5404.301 | 385.592 | 2x130=260 | RH | TVM - KLM | |
| 6 | C6 | 1850 | 5967.533 | 7302.165 | 1334.632 | 2x180=360 | LH | TVM - KLM | |
| 7 | C7 | 10000 | 8797.964 | 9040.514 | 242.55 | 2x50=100 | LH | TVM - KLM | |
| 8 | C8 | 3000 | 11415.119 | 11815.111 | 399.992 | 2x130=260 | RH | TVM - KLM | |
| 9 | C9 | 1850 | 11964.667 | 12690.826 | 726.159 | 2x180=360 | LH | TVM - KLM | |
| 10 | C10 | 3000 | 13369.887 | 14110.467 | 740.58 | 2x130=260 | RH | TVM - KLM | |
| 11 | C11 | 3000 | 14859.296 | 15242.184 | 382.888 | 2x130=260 | RH | TVM - KLM | |
| 12 | C12 | 3000 | 16645.385 | 17624.897 | 979.512 | 2x130=260 | RH | TVM - KLM | |
| 13 | C13 | 15000 | 18343.245 | 18740.033 | 396.788 | 2x120=240 | LH | TVM - KLM | |
| 14 | C14 | 8000 | 19875.085 | 20398.036 | 522.951 | 2x130=260 | RH | TVM - KLM | |
| 15 | C15 | 3000 | 21461.785 | 22416.212 | 954.427 | 2x130=260 | RH | TVM - KLM | |
| 16 | C16 | 2250 | 24338.174 | 25103.793 | 765.619 | 2x200=400 | RH | TVM - KLM | |
| 17 | C17 | 10000 | 26602.043 | 26953.784 | 351.741 | 2x50=100 | LH | TVM - KLM | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 18 | C18 | 3000 | 28822.777 | 29755.515 | 932.738 | 2x130=260 | RH | TVM - KLM | |
| 19 | C19 | 3000 | 31939.249 | 32763.925 | 824.676 | 2x130=260 | LH | TVM - KLM | |
| 20 | C20 | 2250 | 36579.069 | 37959.717 | 1380.648 | 2x200=400 | LH | TVM - KLM | |
| 21 | C21 | 3000 | 39192.089 | 40633.803 | 1441.714 | 2x130=260 | LH | TVM - KLM | |
| 22 | C22 | 3300 | 43999.736 | 44552.936 | 553.2 | 2x130=260 | RH | TVM - KLM | |
| 23 | C23 | 2000 | 45187.512 | 46287.719 | 1100.207 | 2x200=400 | LH | TVM - KLM | |
| 24 | C24 | 2000 | 46533.486 | 47663.142 | 1129.656 | 2x200=400 | RH | TVM - KLM | |
| 25 | C25 | 3000 | 49648.399 | 50382.274 | 733.875 | 2x130=260 | RH | TVM - KLM | |
| 26 | C26 | 650 | 53943.441 | 54466.792 | 523.351 | 2x110=220 | RH | TVM - KLM | Entry of Kollam Station(1) |
| 27 | C27 | 1000 | 56467.348 | 57303.145 | 835.797 | 2x130=260 | RH | KLM - CNGR | Entry of Kollam Station(2) |
| 28 | C28 | 10000 | 58472.575 | 58984.358 | 511.783 | 2x120=240 | LH | KLM - CNGR | |
| 29 | C29 | 3000 | 59708.632 | 60189.143 | 480.511 | 2x130=260 | RH | KLM - CNGR | |
| 30 | C30 | 3000 | 61622.372 | 62709.289 | 1086.917 | 2x130=260 | LH | KLM - CNGR | |
| 31 | C31 | 3000 | 63787.366 | 64528.649 | 741.283 | 2x130=260 | RH | KLM - CNGR | |
| 32 | C32 | 3000 | 65525.159 | 67587.453 | 2062.294 | 2x130=260 | LH | KLM – CNGR | |
| 33 | C33 | 3000 | 72958.582 | 74322.382 | 1363.8 | 2x130=260 | RH | KLM - CNGR | |
| 34 | C34 | 2250 | 76939.603 | 78584.571 | 1644.968 | 2x200=400 | LH | KLM - CNGR | |
| 35 | C35 | 3000 | 81057.605 | 81476.873 | 419.268 | 2x130=260 | RH | KLM - CNGR | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 36 | C36 | 3000 | 85000.499 | 85745.144 | 744.645 | 2x130=260 | LH | KLM - CNGR | |
| 37 | C37 | 3000 | 86454.194 | 88762.992 | 2308.798 | 2x130=260 | RH | KLM - CNGR | |
| 38 | C38 | 8000 | 92013.045 | 92539.374 | 526.329 | 2x120=240 | LH | KLM - CNGR | |
| 39 | C39 | 8000 | 92998.740 | 93410.532 | 411.792 | 2x120=240 | LH | KLM - CNGR | |
| 40 | C40 | 2250 | 94448.160 | 95332.017 | 883.857 | 2x200=400 | LH | KLM - CNGR | |
| 41 | C41 | 8000 | 97061.302 | 97695.422 | 634.12 | 2x120=240 | RH | KLM - CNGR | |
| 42 | C42 | 4000 | 98592.060 | 100049.369 | 1457.309 | 2x130=260 | RH | KLM - CNGR | |
| 43 | C43 | 3000 | 104198.353 | 104572.789 | 374.436 | 2x130=260 | LH | CNGR - KTM | |
| 44 | C44 | 3000 | 107539.596 | 108786.779 | 1247.183 | 2x130=260 | LH | CNGR - KTM | |
| 45 | C45 | 6000 | 109373.099 | 109762.497 | 389.398 | 2x130=260 | RH | CNGR - KTM | |
| 46 | C46 | 4000 | 111324.827 | 111794.866 | 470.039 | 2x130=260 | LH | CNGR - KTM | |
| 47 | C47 | 3000 | 113684.891 | 114311.083 | 626.192 | 2x200=400 | RH | CNGR - KTM | |
| 48 | C48 | 3000 | 118132.259 | 119125.023 | 992.764 | 2x130=260 | LH | CNGR - KTM | |
| 49 | C49 | 10000 | 120393.493 | 120811.660 | 418.167 | 2x120=240 | LH | CNGR - KTM | |
| 50 | C50 | 3000 | 123916.304 | 125232.408 | 1316.104 | 2x130=260 | LH | CNGR - KTM | |
| 51 | C51 | 3000 | 127140.124 | 128956.278 | 1816.154 | 2x130=260 | RH | CNGR - KTM | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 52 | C52 | 3000 | 129938.161 | 131160.477 | 1222.316 | 2x130=260 | LH | CNGR - KTM | |
| 53 | C53 | 3000 | 132662.790 | 134811.265 | 2148.475 | 2x130=260 | RH | CNGR - KTM | |
| 54 | C54 | 3500 | 137008.678 | 137396.008 | 387.33 | 2x130=260 | LH | KTM - EKM | |
| 55 | C55 | 1500 | 137739.202 | 138919.690 | 1180.488 | 2x130=260 | RH | KTM - EKM | Entryof Kottayam Station(3) |
| 56 | C56 | 2500 | 143928.266 | 145050.504 | 1122.238 | 2x150=300 | LH | KTM - EKM | |
| 57 | C57 | 3000 | 146665.349 | 148668.699 | 2003.35 | 2x130=260 | LH | KTM - EKM | |
| 58 | C58 | 3000 | 154524.560 | 155077.959 | 553.399 | 2x130=260 | RH | KTM - EKM | |
| 59 | C59 | 2250 | 158565.617 | 160204.083 | 1638.466 | 2x200=400 | LH | KTM - EKM | |
| 60 | C60 | 3000 | 160958.369 | 162873.590 | 1915.221 | 2x130=260 | RH | KTM - EKM | |
| 61 | C61 | 3000 | 165701.430 | 166686.927 | 985.497 | 2x130=260 | LH | KTM - EKM | |
| 62 | C62 | 3000 | 168995.223 | 169944.505 | 949.282 | 2x130=260 | RH | KTM - EKM | |
| 63 | C63 | 3000 | 174478.790 | 176181.299 | 1702.509 | 2x130=260 | LH | KTM - EKM | |
| 64 | C64 | 2500 | 177649.094 | 178861.204 | 1212.11 | 2x150=300 | LH | KTM - EKM | |
| 65 | C65 | 3000 | 181209.443 | 182805.987 | 1596.544 | 2x130=260 | RH | KTM - EKM | |
| 66 | C66 | 2500 | 184159.312 | 185190.039 | 1030.727 | 2x150=300 | LH | KTM - EKM | |
| 67 | C67 | 2250 | 185535.111 | 187237.983 | 1702.872 | 2x200=400 | RH | KTM - EKM | |
| 68 | C68 | 2250 | 187770.520 | 188636.936 | 866.416 | 2x200=400 | LH | KTM - EKM | |
| 69 | C69 | 1900 | 189202.333 | 191902.642 | 2700.309 | 2x180=360 | RH | KTM - EKM | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 70 | C70 | 2250 | 192822.381 | 193453.468 | 631.087 | 2x200=400 | LH | KTM - EKM | |
| 71 | C71 | 900 | 193853.983 | 194275.257 | 421.274 | 2x130=260 | RH | KTM - EKM | Entry of ernakulam Station(4) |
| 72 | C72 | 2300 | 196197.326 | 197325.088 | 1127.762 | 2x160=320 | LH | EKM - KOA | |
| 73 | C73 | 15000 | 198916.996 | 199249.502 | 332.506 | 2x100=200 | RH | EKM - KOA | |
| 74 | C74 | 3000 | 200151.588 | 200541.242 | 389.654 | 2x130=260 | LH | EKM - KOA | |
| 75 | C75 | 3000 | 204194.841 | 206933.807 | 2738.966 | 2x130=260 | LH | EKM - KOA | |
| 76 | C76 | 2000 | 208698.370 | 210949.220 | 2250.85 | 2x190=380 | RH | EKM - KOA | |
| 77 | C77 | 1850 | 211196.453 | 212143.856 | 947.403 | 2x180=360 | LH | EKM - KOA | |
| 78 | C78 | 3000 | 212759.738 | 213319.316 | 559.578 | 2x130=260 | RH | KOA - TSR | |
| 79 | C79 | 3000 | 213391.229 | 214283.086 | 891.857 | 2x130=260 | LH | KOA - TSR | |
| 80 | C80 | 2250 | 214677.178 | 215677.176 | 999.998 | 2x180=360 | LH | KOA - TSR | |
| 81 | C81 | 3000 | 216497.677 | 217724.349 | 1226.672 | 2x130=260 | LH | KOA - TSR | |
| 82 | C82 | 5000 | 218123.075 | 218570.430 | 447.355 | 2x110=220 | LH | KOA - TSR | |
| 83 | C83 | 13000 | 220286.044 | 220707.178 | 421.134 | 2x100=200 | RH | KOA - TSR | |
| 84 | C84 | 3000 | 224517.147 | 226511.285 | 1994.138 | 2x130=260 | RH | KOA - TSR | |
| 85 | C85 | 3000 | 229261.500 | 229785.613 | 524.113 | 2x130=260 | RH | KOA - TSR | |
| 86 | C86 | 2250 | 233014.964 | 234622.137 | 1607.173 | 2x200=400 | LH | KOA - TSR | |
| 87 | C87 | 2800 | 236450.961 | 238027.743 | 1576.782 | 2x150=300 | RH | KOA - TSR | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 88 | C88 | 2500 | 241867.598 | 243146.684 | 1279.086 | 2x150=300 | LH | KOA - TSR | |
| 89 | C89 | 5000 | 245562.548 | 245864.571 | 302.023 | 2x100=200 | RH | KOA - TSR | |
| 90 | C90 | 3000 | 248474.982 | 251640.127 | 3165.145 | 2x130=260 | RH | KOA - TSR | |
| 91 | C91 | 1900 | 255134.787 | 257187.580 | 2052.793 | 2x190=380 | LH | KOA - TSR | |
| 92 | C92 | 700 | 257480.579 | 258263.982 | 783.403 | 2x110=220 | RH | KOA - TSR | Entry of Thrissur Station(5) |
| 93 | C93 | 1000 | 259635.831 | 259927.253 | 291.422 | 2x130=260 | RH | TSR - TIR | Entry of Thrissur Station(6) |
| 94 | C94 | 650 | 260027.246 | 260482.349 | 455.103 | 2x110=220 | LH | TSR - TIR | Entry of Thrissur Station(7) |
| 95 | C95 | 650 | 260583.948 | 260691.284 | 107.336 | 2x40=80 | LH | TSR - TIR | Entry of Thrissur Station(8) |
| 96 | C96 | 650 | 260745.024 | 261067.616 | 322.592 | 2x110=220 | RH | TSR - TIR | Entry of Thrissur Station(9) |
| 97 | C97 | 2250 | 261864.000 | 262581.427 | 717.427 | 2x200=400 | LH | TSR - TIR | |
| 98 | C98 | 3000 | 263339.792 | 265028.288 | 1688.496 | 2x130=260 | LH | TSR - TIR | |
| 99 | C99 | 3000 | 266058.432 | 267152.225 | 1093.793 | 2x130=260 | LH | TSR - TIR | |
| 100 | C100 | 3000 | 269195.291 | 270111.029 | 915.738 | 2x130=260 | RH | TSR - TIR | |
| 101 | C101 | 3000 | 271919.281 | 273289.013 | 1369.732 | 2x130=260 | LH | TSR - TIR | |
| 102 | C102 | 3000 | 275034.345 | 275810.258 | 775.913 | 2x130=260 | RH | TSR - TIR | |
| 103 | C103 | 10000 | 277417.258 | 278035.470 | 618.212 | 2x100=200 | LH | TSR - TIR | |
| 104 | C104 | 3000 | 278873.521 | 279719.257 | 845.736 | 2x130=260 | RH | TSR - TIR | |
| 105 | C105 | 3000 | 284382.123 | 285287.957 | 905.834 | 2x130=260 | RH | TSR - TIR | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 106 | C106 | 3000 | 290783.237 | 291569.174 | 785.937 | 2x130=260 | LH | TSR - TIR | |
| 107 | C107 | 3000 | 293545.455 | 294884.443 | 1338.988 | 2x130=260 | RH | TSR - TIR | |
| 108 | C108 | 3000 | 298623.245 | 299082.756 | 459.511 | 2x130=260 | LH | TSR - TIR | |
| 109 | C109 | 3000 | 305339.216 | 305722.309 | 383.093 | 2x130=260 | LH | TSR - TIR | |
| 110 | C110 | 2250 | 308060.764 | 310070.736 | 2009.972 | 2x200=400 | LH | TSR - TIR | |
| 111 | C111 | 3000 | 310480.316 | 311674.849 | 1194.533 | 2x130=260 | RH | TSR - TIR | |
| 112 | C112 | 3000 | 314517.860 | 315639.003 | 1121.143 | 2x130=260 | RH | TSR - TIR | |
| 113 | C113 | 3000 | 319043.353 | 319375.570 | 332.217 | 2x130=260 | LH | TSR - TIR | |
| 114 | C114 | 3000 | 319494.485 | 319824.465 | 329.98 | 2x130=260 | RH | TSR - TIR | |
| 115 | C115 | 5000 | 322319.915 | 322612.371 | 292.456 | 2x90=180 | RH | TIR - KKD | |
| 116 | C116 | 10000 | 322964.047 | 323400.415 | 436.368 | 2x50=100 | LH | TIR - KKD | |
| 117 | C117 | 3000 | 324688.874 | 325948.362 | 1259.488 | 2x130=260 | RH | TIR - KKD | |
| 118 | C118 | 10000 | 328660.408 | 328844.420 | 184.012 | 2x50=100 | RH | TIR - KKD | |
| 119 | C119 | 10000 | 329414.528 | 329821.760 | 407.232 | 2x50=100 | LH | TIR - KKD | |
| 120 | C120 | 3000 | 330371.067 | 331184.130 | 813.063 | 2x130=260 | LH | TIR - KKD | |
| 121 | C121 | 2000 | 333239.630 | 334211.016 | 971.386 | 2x190=380 | RH | TIR - KKD | |
| 122 | C122 | 3000 | 336513.021 | 337946.771 | 1433.75 | 2x130=260 | LH | TIR - KKD | |
| 123 | C123 | 10000 | 341545.131 | 341947.757 | 402.626 | 2x50=100 | LH | TIR - KKD | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 124 | C124 | 1850 | 342921.828 | 344473.820 | 1551.992 | 2x180=360 | RH | TIR - KKD | |
| 125 | C125 | 3000 | 345343.855 | 345656.231 | 312.376 | 2x130=260 | LH | TIR - KKD | |
| 126 | C126 | 2250 | 346594.607 | 347060.760 | 466.153 | 2x200=400 | LH | TIR - KKD | |
| 127 | C127 | 2250 | 347217.986 | 348074.304 | 856.318 | 2x200=400 | LH | TIR - KKD | |
| 128 | C128 | 1850 | 348453.804 | 349721.281 | 1267.477 | 2x180=360 | LH | TIR - KKD | |
| 129 | C129 | 3000 | 352438.199 | 352819.667 | 381.468 | 2x130=260 | LH | TIR - KKD | |
| 130 | C130 | 1850 | 352958.121 | 354421.054 | 1462.933 | 2x180=360 | RH | TIR - KKD | |
| 131 | C131 | 5000 | 354660.283 | 355198.627 | 538.344 | 2x100=200 | LH | TIR - KKD | |
| 132 | C132 | 1900 | 355479.064 | 356564.106 | 1085.042 | 2x190=380 | LH | TIR - KKD | |
| 133 | C133 | 650 | 356880.452 | 357388.113 | 507.661 | 2x110=220 | RH | TIR - KKD | Entry of Kozhikode Station(10) |
| 134 | C134 | 1000 | 358492.023 | 358803.162 | 311.139 | 2x110=220 | LH | KKD - KNR | Entry of Kozhikode Station(11) |
| 135 | C135 | 3200 | 360169.895 | 360464.069 | 294.174 | 2x130=260 | LH | KKD - KNR | |
| 136 | C136 | 3500 | 360841.291 | 361134.756 | 293.465 | 2x130=260 | RH | KKD - KNR | |
| 137 | C137 | 3000 | 363038.485 | 363339.770 | 301.285 | 2x130=260 | RH | KKD - KNR | |
| 138 | C138 | 3000 | 363613.916 | 363910.867 | 296.951 | 2x130=260 | LH | KKD - KNR | |
| 139 | C139 | 5000 | 366419.771 | 367100.774 | 681.003 | 2x130=260 | LH | KKD - KNR | |
| 140 | C140 | 2250 | 368230.369 | 369442.228 | 1211.859 | 2x200=400 | RH | KKD - KNR | |
| 141 | C141 | 2250 | 371815.856 | 373043.701 | 1227.845 | 2x200=400 | LH | KKD - KNR | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 142 | C142 | 2250 | 380679.462 | 381404.198 | 724.736 | 2x200=400 | LH | KKD - KNR | |
| 143 | C143 | 1860 | 383971.071 | 384811.277 | 840.206 | 2x190=380 | LH | KKD - KNR | |
| 144 | C144 | 2000 | 386388.887 | 387555.346 | 1166.459 | 2x190=380 | LH | KKD - KNR | |
| 145 | C145 | 2000 | 388266.779 | 391063.167 | 2796.388 | 2x180=360 | RH | KKD - KNR | |
| 146 | C146 | 10000 | 398363.621 | 399508.690 | 1145.069 | 2x140=280 | RH | KKD - KNR | |
| 147 | C147 | 2500 | 399938.526 | 401438.507 | 1499.981 | 2x170=340 | LH | KKD - KNR | |
| 148 | C148 | 1900 | 402969.174 | 403733.693 | 764.519 | 2x180=360 | RH | KKD - KNR | |
| 149 | C149 | 8000 | 404512.325 | 404947.867 | 435.542 | 2x110=220 | LH | KKD - KNR | |
| 150 | C150 | 1900 | 405936.815 | 407136.462 | 1199.647 | 2x190=380 | RH | KKD - KNR | |
| 151 | C151 | 2000 | 407644.954 | 408526.783 | 881.829 | 2x190=380 | LH | KKD - KNR | |
| 152 | C152 | 1900 | 410135.656 | 411008.305 | 872.649 | 2x190=380 | LH | KKD - KNR | |
| 153 | C153 | 2000 | 414300.433 | 415317.784 | 1017.351 | 2x190=380 | RH | KKD - KNR | |
| 154 | C154 | 1900 | 416801.862 | 419176.410 | 2374.548 | 2x190=380 | LH | KKD - KNR | |
| 155 | C155 | 2000 | 419571.507 | 421149.269 | 1577.762 | 2x190=380 | RH | KKD - KNR | |
| 156 | C156 | 2000 | 426554.016 | 427633.066 | 1079.05 | 2x190=380 | LH | KKD - KNR | |
| 157 | C157 | 1900 | 428400.345 | 429554.760 | 1154.415 | 2x190=380 | RH | KKD - KNR | |
| 158 | C158 | 4000 | 429766.449 | 430515.066 | 748.617 | 2x150=300 | LH | KKD - KNR | |
| 159 | C159 | 2500 | 431140.215 | 431947.749 | 807.534 | 2x180=360 | RH | KKD - KNR | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 160 | C160 | 2000 | 432747.632 | 433396.023 | 648.391 | 2x190=380 | LH | KKD - KNR | Entry of Kannur Station |
| 161 | C161 | 1900 | 434276.887 | 435444.729 | 1167.842 | 2x190=380 | RH | KKD - KNR | Entry of Kannur Station |
| 162 | C162 | 2300 | 437285.286 | 438956.687 | 1291.400 | 2x190=380 | LH | KKD - KNR | Entry of Kannur Station |
| 163 | C163 | 3000 | 440668.483 | 441040.384 | 371.901 | 2x130=260 | RH | KKD - KNR | |
| 164 | C164 | 2750 | 441585.101 | 444007.328 | 2422.227 | 2x140=280 | LH | KKD - KNR | |
| 165 | C165 | 1500 | 444239.868 | 444934.170 | 694.302 | 2x180=360 | LH | KKD - KNR | Entry of Kannur Station(12) |
| 166 | C166 | 900 | 445283.423 | 446429.118 | 1145.695 | 2x130=260 | RH | KKD - KNR | Entry of Kannur Station(13) |
| 167 | C167 | 650 | 447518.706 | 447966.321 | 447.615 | 2x110=220 | RH | KNR - KGD | Entry of Kannur Station(14) |
| 168 | C168 | 3000 | 449982.254 | 450317.708 | 335.454 | 2x130=260 | LH | KNR - KGD | |
| 169 | C169 | 1850 | 451416.477 | 452237.328 | 820.851 | 2x180=360 | LH | KNR - KGD | |
| 170 | C170 | 1900 | 452274.666 | 453953.468 | 1678.802 | 2x190=380 | RH | KNR - KGD | |
| 171 | C171 | 2000 | 454835.396 | 456589.789 | 1754.393 | 2x180=360 | LH | KNR - KGD | |
| 172 | C172 | 1850 | 462289.178 | 463651.879 | 1362.701 | 2x180=360 | LH | KNR - KGD | |
| 173 | C173 | 1850 | 463841.710 | 465270.070 | 1428.36 | 2x180=360 | RH | KNR - KGD | |
| 174 | C174 | 7500 | 466426.588 | 466745.763 | 319.175 | 2x100=200 | RH | KNR - KGD | |
| 175 | C175 | 5000 | 467347.335 | 467650.044 | 302.709 | 2x100=200 | LH | KNR - KGD | |
| 176 | C176 | 3000 | 468220.549 | 468631.652 | 411.103 | 2x130=260 | LH | KNR - KGD | |
| 177 | C177 | 3000 | 470789.445 | 471428.500 | 639.055 | 2x130=260 | RH | KNR - KGD | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 178 | C178 | 2000 | 473518.649 | 474783.323 | 1264.674 | 2x180=360 | LH | KNR - KGD | |
| 179 | C179 | 2250 | 477457.387 | 479370.429 | 1913.042 | 2x200=400 | RH | KNR - KGD | |
| 180 | C180 | 3000 | 482529.224 | 482835.662 | 306.438 | 2x130=260 | LH | KNR - KGD | |
| 181 | C181 | 2250 | 484353.116 | 485374.847 | 1021.731 | 2x200=400 | RH | KNR - KGD | |
| 182 | C182 | 1850 | 488077.565 | 489294.193 | 1216.628 | 2x180=360 | LH | KNR - KGD | |
| 183 | C183 | 2250 | 490592.361 | 491877.705 | 1285.344 | 2x200=400 | RH | KNR - KGD | |
| 184 | C184 | 3000 | 492867.442 | 493703.634 | 836.192 | 2x130=260 | LH | KNR - KGD | |
| 185 | C185 | 3000 | 494180.515 | 494654.534 | 474.019 | 2x130=260 | RH | KNR - KGD | |
| 186 | C186 | 1850 | 496617.899 | 497466.798 | 848.899 | 2x180=360 | LH | KNR - KGD | |
| 187 | C187 | 1850 | 499349.874 | 500884.042 | 1534.168 | 2x180=360 | LH | KNR - KGD | |
| 188 | C188 | 1850 | 501027.178 | 502793.059 | 1765.881 | 2x180=360 | RH | KNR - KGD | |
| 189 | C189 | 3000 | 506584.966 | 507005.133 | 420.167 | 2x130=260 | RH | KNR - KGD | |
| 190 | C190 | 1850 | 511114.699 | 511930.846 | 816.147 | 2x180=360 | LH | KNR - KGD | |
| 191 | C191 | 2250 | 512438.121 | 513439.582 | 1001.461 | 2x200=400 | RH | KNR - KGD | |
| 192 | C192 | 2000 | 513614.003 | 514258.516 | 644.513 | 2x180=360 | LH | KNR - KGD | |
| 193 | C193 | 3000 | 514360.445 | 514854.471 | 494.026 | 2x130=260 | LH | KNR - KGD | |
| 194 | C194 | 2250 | 516011.692 | 517029.174 | 1017.482 | 2x200=400 | RH | KNR - KGD | |
| 195 | C195 | 2000 | 517765.484 | 518494.098 | 728.614 | 2x190=380 | LH | KNR - KGD | |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 196 | C196 | 2250 | 519079.596 | 520787.431 | 1707.835 | 2x200=400 | RH | KNR - KGD | |
| 197 | C197 | 2250 | 521223.595 | 523291.777 | 2068.182 | 2x200=400 | LH | KNR - KGD | |
| 198 | C198 | 2000 | 525955.849 | 527409.281 | 1453.432 | 2x180=360 | RH | KNR - KGD | |
| 199 | C199 | 1000 | 528621.258 | 529417.064 | 795.806 | 2x140=280 | LH | KNR - KGD | Entry of Kasaragod Station(15) |
| 200 | C200 | 650 | 529544.023 | 529911.354 | 367.331 | 2x110=220 | RH | KNR - KGD | Entry of Kasaragod Station(16) |
| 201 | C201 | 650 | 531354.204 | 531797.503 | 443.299 | 2x110=220 | LH | KGD - KDD | Entry of Kasaragod Station beyond Kasaragod |

**Detailed Summary of Horizontal Curves**

| | | |
|---|---|---|
| 1 | **Total No of Horizontal curves on Main Line BetweenTVM-KGD (Curve No 2-200)** | **199 Nos** |
| 2 | Total length of Horizontal curves on Main Line BetweenTVM-KGD (Curve Nos 2-200) | 194.319 Km |
| 3 | Total length of Main Line Between TVM-KGD | 529.450 Km |
| 4 | Percentage of Horizontal Curves Between TVM-KGD (Curve Nos 2-200) | 36.70% |
| 4 | Total No of Horizontal curves on Main Line From Begning to End (Curve Nos 1-201) | 201 Nos |
| 5 | Total length of Horizontal curves on Main Line From Begning To End on Main Line (Curve Nos 1-201) | 194.975 Km |
| 6 | Total length of Main Line From Begning To End on Main Line | 532.185 Km |
| 7 | Percentage of Horizontal Curves From Begning To End on Main Line | 36.64% |

| Sl No. | Curve No. | Radius of Curve(m) | Chainage (M) | | Curve Length (m) | Transition length (m) | LH/RH | Between Stations | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Start | End | | | | | |
| 8 | Total No of Sharp Horizontal curves of Radius Less Than 1850m on Main Line BetweenTVM-KGD | | | | | | | | 16 Nos |
| 9 | Total Length of Sharp Horizontal curves of Radius Less Than 1850 m on Main Line Between TVM-KGD | | | | | | | | 9.190 Km |
| 10 | Percentage of Sharp Horizontal curves of Radius Less than 1850 on Main Line Between:TVM-KGD | | | | | | | | 4.71% |

**Table 6-50: Details of vertical alignment geometry and gradients**

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | POB | -1+100.000 | 11.5 | 0.00% | PVC | 2+041.320 | 11.5 | 0.00% | Linear | | 3141.320 | TVA-TVM | |
| 2 | PVC | 2+041.320 | 11.5 | 0.00% | PVT | 2+252.876 | 11.28 | -0.21% | Circular | VC1 | 211.556 | TVM-KLM | 100000.000 |
| 3 | PVT | 2+252.876 | 11.28 | -0.21% | PVC | 4+001.884 | 7.58 | -0.21% | Linear | | 1749.008 | TVM-KLM | |
| 4 | PVC | 4+001.884 | 7.58 | -0.21% | PVT | 4+197.986 | 7.55 | 0.18% | Circular | VC2 | 196.102 | TVM-KLM | -50000.000 |
| 5 | PVT | 4+197.986 | 7.55 | 0.18% | PVC | 5+554.859 | 10 | 0.18% | Linear | | 1356.873 | TVM-KLM | |
| 6 | PVC | 5+554.859 | 10 | 0.18% | PVT | 5+684.705 | 10.12 | 0.01% | Circular | VC3 | 129.846 | TVM-KLM | 75000.000 |
| 7 | PVT | 5+684.705 | 10.12 | 0.01% | PVC | 8+462.559 | 10.33 | 0.01% | Linear | | 2777.854 | TVM-KLM | |
| 8 | PVC | 8+462.559 | 10.33 | 0.01% | PVT | 8+561.692 | 10.32 | -0.03% | Circular | VC4 | 99.133 | TVM-KLM | 300000.000 |
| 9 | PVT | 8+561.692 | 10.32 | -0.03% | PVC | 10+047.786 | 9.94 | -0.03% | Linear | | 1486.095 | TVM-KLM | |
| 10 | PVC | 10+047.786 | 9.94 | -0.03% | PVT | 10+166.081 | 9.92 | -0.01% | Circular | VC5 | 118.295 | TVM-KLM | -765000.000 |
| 11 | PVT | 10+166.081 | 9.92 | -0.01% | PVC | 13+200.241 | 9.61 | -0.01% | Linear | | 3034.159 | TVM-KLM | |
| 12 | PVC | 13+200.241 | 9.61 | -0.01% | PVT | 13+306.368 | 9.49 | -0.21% | Circular | VC6 | 106.128 | TVM-KLM | 52000.000 |
| 13 | PVT | 13+306.368 | 9.49 | -0.21% | PVC | 14+635.054 | 6.65 | -0.21% | Linear | | 1328.686 | TVM-KLM | |
| 14 | PVC | 14+635.054 | 6.65 | -0.21% | PVT | 14+823.857 | 7.23 | 0.83% | Circular | VC7 | 188.803 | TVM-KLM | -18000.000 |
| 15 | PVT | 14+823.857 | 7.23 | 0.83% | PVC | 16+980.775 | 25.24 | 0.83% | Linear | | 2156.918 | TVM-KLM | |
| 16 | PVC | 16+980.775 | 25.24 | 0.83% | PVT | 17+317.435 | 24.9 | -1.04% | Circular | VC8 | 336.660 | TVM-KLM | 18000.000 |
| 17 | PVT | 17+317.435 | 24.9 | -1.04% | PVC | 18+872.765 | 8.79 | -1.04% | Linear | | 1555.330 | TVM-KLM | |
| 18 | PVC | 18+872.765 | 8.79 | -1.04% | PVT | 19+148.764 | 8.05 | 0.50% | Circular | VC9 | 275.998 | TVM-KLM | -18000.000 |
| 19 | PVT | 19+148.764 | 8.05 | 0.50% | PVC | 20+057.786 | 12.58 | 0.50% | Linear | | 909.022 | TVM-KLM | |
| 20 | PVC | 20+057.786 | 12.58 | 0.50% | PVT | 20+185.349 | 12.81 | -0.13% | Circular | VC10 | 127.564 | TVM-KLM | 20350.000 |
| 21 | PVT | 20+185.349 | 12.81 | -0.13% | PVC | 23+627.745 | 8.37 | -0.13% | Linear | | 3442.396 | TVM-KLM | |
| 22 | PVC | 23+627.745 | 8.37 | -0.13% | PVT | 23+853.144 | 8.94 | 0.63% | Circular | VC11 | 225.399 | TVM-KLM | -29570.000 |
| 23 | PVT | 23+853.144 | 8.94 | 0.63% | PVC | 26+300.582 | 24.43 | 0.63% | Linear | | 2447.438 | TVM-KLM | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | PVC | 26+300.582 | 24.43 | 0.63% | PVT | 26+468.592 | 25.16 | 0.23% | Circular | VC12 | 168.009 | TVM-KLM | 41630.000 |
| 25 | PVT | 26+468.592 | 25.16 | 0.23% | PVC | 29+014.342 | 31 | 0.23% | Linear | | 2545.751 | TVM-KLM | |
| 26 | PVC | 29+014.342 | 31 | 0.23% | PVT | 29+147.313 | 31.39 | 0.35% | Circular | VC13 | 132.970 | TVM-KLM | -112000.000 |
| 27 | PVT | 29+147.313 | 31.39 | 0.35% | PVC | 32+254.596 | 42.21 | 0.35% | Linear | | 3107.283 | TVM-KLM | |
| 28 | PVC | 32+254.596 | 42.21 | 0.35% | PVT | 32+352.202 | 42.67 | 0.60% | Circular | VC14 | 97.606 | TVM-KLM | -39000.000 |
| 29 | PVT | 32+352.202 | 42.67 | 0.60% | PVC | 36+852.172 | 69.61 | 0.60% | Linear | | 4499.971 | TVM-KLM | |
| 30 | PVC | 36+852.172 | 69.61 | 0.60% | PVT | 37+214.422 | 68.13 | -1.41% | Circular | VC15 | 362.250 | TVM-KLM | 18000.000 |
| 31 | PVT | 37+214.422 | 68.13 | -1.41% | PVC | 38+731.179 | 46.68 | -1.41% | Linear | | 1516.757 | TVM-KLM | |
| 32 | PVC | 38+731.179 | 46.68 | -1.41% | PVT | 38+988.041 | 44.88 | 0.01% | Circular | VC16 | 256.862 | TVM-KLM | -18000.000 |
| 33 | PVT | 38+988.041 | 44.88 | 0.01% | PVC | 40+033.598 | 45.02 | 0.01% | Linear | | 1045.557 | TVM-KLM | |
| 34 | PVC | 40+033.598 | 45.02 | 0.01% | PVT | 40+149.977 | 44.66 | -0.63% | Circular | VC17 | 116.379 | TVM-KLM | 18000.000 |
| 35 | PVT | 40+149.977 | 44.66 | -0.63% | PVC | 41+642.588 | 35.2 | -0.63% | Linear | | 1492.611 | TVM-KLM | |
| 36 | PVC | 41+642.588 | 35.2 | -0.63% | PVT | 41+786.347 | 34.86 | 0.17% | Circular | VC18 | 143.759 | TVM-KLM | -18000.000 |
| 37 | PVT | 41+786.347 | 34.86 | 0.17% | PVC | 45+556.629 | 41.09 | 0.17% | Linear | | 3770.282 | TVM-KLM | |
| 38 | PVC | 45+556.629 | 41.09 | 0.17% | PVT | 45+811.346 | 39.71 | -1.25% | Circular | VC19 | 254.717 | TVM-KLM | 18000.000 |
| 39 | PVT | 45+811.346 | 39.71 | -1.25% | PVC | 48+110.266 | 10.98 | -1.25% | Linear | | 2298.919 | TVM-KLM | |
| 40 | PVC | 48+110.266 | 10.98 | -1.25% | PVT | 48+395.134 | 9.67 | 0.33% | Circular | VC20 | 284.869 | TVM-KLM | -18000.000 |
| 41 | PVT | 48+395.134 | 9.67 | 0.33% | PVC | 51+328.356 | 19.43 | 0.33% | Linear | | 2933.221 | TVM-KLM | |
| 42 | PVC | 51+328.356 | 19.43 | 0.33% | PVT | 51+460.241 | 19.38 | -0.40% | Circular | VC21 | 131.886 | TVM-KLM | 18000.000 |
| 43 | PVT | 51+460.241 | 19.38 | -0.40% | PVC | 53+047.941 | 13.03 | -0.40% | Linear | | 1587.700 | TVM-KLM | |
| 44 | PVC | 53+047.941 | 13.03 | -0.40% | PVT | 53+092.831 | 12.84 | -0.44% | Circular | VC22 | 44.890 | TVM-KLM | 125000.000 |
| 45 | PVT | 53+092.831 | 12.84 | -0.44% | PVC | 54+136.600 | 8.29 | -0.44% | Linear | | 1043.769 | TVM-KLM | |
| 46 | PVC | 54+136.600 | 8.29 | -0.44% | PVT | 54+267.282 | 8.01 | 0.00% | Circular | VC23 | 130.683 | TVM-KLM | -30000.000 |
| 47 | PVT | 54+267.282 | 8.01 | 0.00% | PVC | 57+836.174 | 8 | 0.00% | Linear | | 3568.892 | KLM - CNGR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | PVC | 57+836.174 | 8 | 0.00% | PVT | 58+002.159 | 8.34 | 0.41% | Circular | VC24 | 165.984 | KLM - CNGR | -40000.000 |
| 49 | PVT | 58+002.159 | 8.34 | 0.41% | PVC | 62+353.833 | 26.39 | 0.41% | Linear | | 4351.674 | KLM - CNGR | |
| 50 | PVC | 62+353.833 | 26.39 | 0.41% | PVT | 62+478.218 | 26.5 | -0.24% | Circular | VC25 | 124.385 | KLM - CNGR | 19000.000 |
| 51 | PVT | 62+478.218 | 26.5 | -0.24% | PVC | 64+062.636 | 22.69 | -0.24% | Linear | | 1584.418 | KLM - CNGR | |
| 52 | PVC | 64+062.636 | 22.69 | -0.24% | PVT | 64+239.076 | 23.14 | 0.74% | Circular | VC26 | 176.440 | KLM - CNGR | -18000.000 |
| 53 | PVT | 64+239.076 | 23.14 | 0.74% | PVC | 65+676.212 | 33.77 | 0.74% | Linear | | 1437.136 | KLM - CNGR | |
| 54 | PVC | 65+676.212 | 33.77 | 0.74% | PVT | 65+980.445 | 33.45 | -0.95% | Circular | VC27 | 304.232 | KLM - CNGR | 18000.000 |
| 55 | PVT | 65+980.445 | 33.45 | -0.95% | PVC | 67+792.090 | 16.24 | -0.95% | Linear | | 1811.646 | KLM - CNGR | |
| 56 | PVC | 67+792.090 | 16.24 | -0.95% | PVT | 67+978.082 | 15.34 | -0.02% | Circular | VC28 | 185.991 | KLM - CNGR | -20000.000 |
| 57 | PVT | 67+978.082 | 15.34 | -0.02% | PVC | 72+275.874 | 14.48 | -0.02% | Linear | | 4297.792 | KLM - CNGR | |
| 58 | PVC | 72+275.874 | 14.48 | -0.02% | PVT | 72+419.870 | 14.97 | 0.70% | Circular | VC29 | 143.997 | KLM - CNGR | -20000.000 |
| 59 | PVT | 72+419.870 | 14.97 | 0.70% | PVC | 75+115.078 | 33.84 | 0.70% | Linear | | 2695.207 | KLM - CNGR | |
| 60 | PVC | 75+115.078 | 33.84 | 0.70% | PVT | 75+224.483 | 34.4 | 0.34% | Circular | VC30 | 109.406 | KLM - CNGR | 30000.000 |
| 61 | PVT | 75+224.483 | 34.4 | 0.34% | PVC | 76+401.202 | 38.35 | 0.34% | Linear | | 1176.719 | KLM - CNGR | |
| 62 | PVC | 76+401.202 | 38.35 | 0.34% | PVT | 76+732.239 | 36.72 | -1.32% | Circular | VC31 | 331.036 | KLM - CNGR | 20000.000 |
| 63 | PVT | 76+732.239 | 36.72 | -1.32% | PVC | 77+794.966 | 22.69 | -1.32% | Linear | | 1062.727 | KLM - CNGR | |
| 64 | PVC | 77+794.966 | 22.69 | -1.32% | PVT | 78+239.025 | 21.76 | 0.90% | Circular | VC32 | 444.059 | KLM - CNGR | -20000.000 |
| 65 | PVT | 78+239.025 | 21.76 | 0.90% | PVC | 79+527.565 | 33.36 | 0.90% | Linear | | 1288.539 | KLM - CNGR | |
| 66 | PVC | 79+527.565 | 33.36 | 0.90% | PVT | 79+887.640 | 33.36 | -0.90% | Circular | VC33 | 360.075 | KLM - CNGR | 20000.000 |
| 67 | PVT | 79+887.640 | 33.36 | -0.90% | PVC | 81+669.325 | 17.33 | -0.90% | Linear | | 1781.685 | KLM - CNGR | |
| 68 | PVC | 81+669.325 | 17.33 | -0.90% | PVT | 81+859.318 | 16.52 | 0.05% | Circular | VC34 | 189.993 | KLM - CNGR | -20000.000 |
| 69 | PVT | 81+859.318 | 16.52 | 0.05% | PVC | 84+712.050 | 17.95 | 0.05% | Linear | | 2852.732 | KLM - CNGR | |
| 70 | PVC | 84+712.050 | 17.95 | 0.05% | PVT | 84+862.046 | 18.47 | 0.65% | Circular | VC35 | 149.997 | KLM - CNGR | -25000.000 |
| 71 | PVT | 84+862.046 | 18.47 | 0.65% | PVC | 86+931.666 | 31.93 | 0.65% | Linear | | 2069.620 | KLM - CNGR | |
| 72 | PVC | 86+931.666 | 31.93 | 0.65% | PVT | 87+209.659 | 31.8 | -0.74% | Circular | VC36 | 277.993 | KLM - CNGR | 20000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73 | PVT | 87+209.659 | 31.8 | -0.74% | PVC | 89+660.264 | 13.67 | -0.74% | Linear | | 2450.604 | KLM - CNGR | |
| 74 | PVC | 89+660.264 | 13.67 | -0.74% | PVT | 89+806.259 | 13.12 | -0.01% | Circular | VC37 | 145.996 | KLM - CNGR | -20000.000 |
| 75 | PVT | 89+806.259 | 13.12 | -0.01% | PVC | 95+886.513 | 12.51 | -0.01% | Linear | | 6080.254 | KLM - CNGR | |
| 76 | PVC | 95+886.513 | 12.51 | -0.01% | PVT | 96+135.641 | 14.21 | 1.37% | Circular | VC38 | 249.127 | KLM - CNGR | -18000.000 |
| 77 | PVT | 96+135.641 | 14.21 | 1.37% | PVC | 98+025.433 | 40.18 | 1.37% | Linear | | 1889.792 | KLM - CNGR | |
| 78 | PVC | 98+025.433 | 40.18 | 1.37% | PVT | 98+401.215 | 41.42 | -0.71% | Circular | VC39 | 375.782 | KLM - CNGR | 18000.000 |
| 79 | PVT | 98+401.215 | 41.42 | -0.71% | PVC | 101+839.776 | 16.88 | -0.71% | Linear | | 3438.561 | KLM - CNGR | |
| 80 | PVC | 101+839.776 | 16.88 | -0.71% | PVT | 101+968.231 | 16.42 | 0.00% | Circular | VC40 | 128.454 | KLM - CNGR | -18000.000 |
| 81 | PVT | 101+968.231 | 16.42 | 0.00% | PVC | 103+825.392 | 16.42 | 0.00% | Linear | | 1857.162 | CNGR - KTM | |
| 82 | PVC | 103+825.392 | 16.42 | 0.00% | PVT | 103+895.150 | 16.41 | -0.05% | Circular | VC41 | 69.758 | CNGR - KTM | 150000.000 |
| 83 | PVT | 103+895.150 | 16.41 | -0.05% | PVC | 108+895.230 | 14.08 | -0.05% | Linear | | 5000.080 | CNGR - KTM | |
| 84 | PVC | 108+895.230 | 14.08 | -0.05% | PVT | 108+969.924 | 13.99 | -0.20% | Circular | VC42 | 74.695 | CNGR - KTM | 50000.000 |
| 85 | PVT | 108+969.924 | 13.99 | -0.20% | PVC | 110+901.931 | 10.21 | -0.20% | Linear | | 1932.007 | CNGR - KTM | |
| 86 | PVC | 110+901.931 | 10.21 | -0.20% | PVT | 111+104.100 | 10.01 | 0.01% | Circular | VC43 | 202.169 | CNGR - KTM | -100000.000 |
| 87 | PVT | 111+104.100 | 10.01 | 0.01% | PVC | 112+707.814 | 10.11 | 0.01% | Linear | | 1603.715 | CNGR - KTM | |
| 88 | PVC | 112+707.814 | 10.11 | 0.01% | PVT | 112+803.222 | 10.18 | 0.13% | Circular | VC44 | 95.408 | CNGR - KTM | -77000.000 |
| 89 | PVT | 112+803.222 | 10.18 | 0.13% | PVC | 113+901.321 | 11.61 | 0.13% | Linear | | 1098.099 | CNGR - KTM | |
| 90 | PVC | 113+901.321 | 11.61 | 0.13% | PVT | 114+064.243 | 11.19 | -0.65% | Circular | VC45 | 162.923 | CNGR - KTM | 21000.000 |
| 91 | PVT | 114+064.243 | 11.19 | -0.65% | PVC | 114+779.669 | 6.57 | -0.65% | Linear | | 715.426 | CNGR - KTM | |
| 92 | PVC | 114+779.669 | 6.57 | -0.65% | PVT | 115+085.873 | 7.2 | 1.06% | Circular | VC46 | 306.204 | CNGR - KTM | -18000.000 |
| 93 | PVT | 115+085.873 | 7.2 | 1.06% | PVC | 116+042.623 | 17.3 | 1.06% | Linear | | 956.750 | CNGR - KTM | |
| 94 | PVC | 116+042.623 | 17.3 | 1.06% | PVT | 116+173.997 | 18.2 | 0.33% | Circular | VC47 | 131.374 | CNGR - KTM | 18000.000 |
| 95 | PVT | 116+173.997 | 18.2 | 0.33% | PVC | 117+478.967 | 22.45 | 0.33% | Linear | | 1304.970 | CNGR - KTM | |
| 96 | PVC | 117+478.967 | 22.45 | 0.33% | PVT | 117+586.869 | 22.89 | 0.48% | Circular | VC48 | 107.902 | CNGR - KTM | -70000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97 | PVT | 117+586.869 | 22.89 | 0.48% | PVC | 118+639.534 | 27.94 | 0.48% | Linear | | 1052.665 | CNGR - KTM | |
| 98 | PVC | 118+639.534 | 27.94 | 0.48% | PVT | 118+751.437 | 28.13 | -0.14% | Circular | VC49 | 111.903 | CNGR - KTM | 18000.000 |
| 99 | PVT | 118+751.437 | 28.13 | -0.14% | PVC | 119+617.564 | 26.9 | -0.14% | Linear | | 866.127 | CNGR - KTM | |
| 100 | PVC | 119+617.564 | 26.9 | -0.14% | PVT | 119+880.978 | 28.45 | 1.32% | Circular | VC50 | 263.414 | CNGR - KTM | -18000.000 |
| 101 | PVT | 119+880.978 | 28.45 | 1.32% | PVC | 120+647.365 | 38.58 | 1.32% | Linear | | 766.386 | CNGR - KTM | |
| 102 | PVC | 120+647.365 | 38.58 | 1.32% | PVT | 120+926.568 | 40.1 | -0.23% | Circular | VC51 | 279.204 | CNGR - KTM | 17500.000 |
| 103 | PVT | 120+926.568 | 40.1 | -0.23% | PVC | 121+866.684 | 37.95 | -0.23% | Linear | | 940.115 | CNGR - KTM | |
| 104 | PVC | 121+866.684 | 37.95 | -0.23% | PVT | 121+999.699 | 37.73 | -0.10% | Circular | VC52 | 133.016 | CNGR - KTM | -25000.000 |
| 105 | PVT | 121+999.699 | 37.73 | -0.10% | PVC | 122+839.343 | 36.92 | -0.10% | Linear | | 839.643 | CNGR - KTM | |
| 106 | PVC | 122+839.343 | 36.92 | -0.10% | PVT | 123+050.723 | 35.47 | -1.27% | Circular | VC53 | 211.381 | CNGR - KTM | 18000.000 |
| 107 | PVT | 123+050.723 | 35.47 | -1.27% | PVC | 124+060.412 | 22.64 | -1.27% | Linear | | 1009.688 | CNGR - KTM | |
| 108 | PVC | 124+060.412 | 22.64 | -1.27% | PVT | 124+370.428 | 21.37 | 0.45% | Circular | VC54 | 310.017 | CNGR - KTM | -18000.000 |
| 109 | PVT | 124+370.428 | 21.37 | 0.45% | PVC | 125+633.526 | 27.07 | 0.45% | Linear | | 1263.097 | CNGR - KTM | |
| 110 | PVC | 125+633.526 | 27.07 | 0.45% | PVT | 125+976.580 | 25.35 | -1.45% | Circular | VC55 | 343.055 | CNGR - KTM | 18000.000 |
| 111 | PVT | 125+976.580 | 25.35 | -1.45% | PVC | 127+501.178 | 3.17 | -1.45% | Linear | | 1524.598 | CNGR - KTM | |
| 112 | PVC | 127+501.178 | 3.17 | -1.45% | PVT | 127+780.398 | 1.28 | 0.10% | Circular | VC56 | 279.220 | CNGR - KTM | -18000.000 |
| 113 | PVT | 127+780.398 | 1.28 | 0.10% | PVC | 131+928.624 | 5.29 | 0.10% | Linear | | 4148.225 | CNGR - KTM | |
| 114 | PVC | 131+928.624 | 5.29 | 0.10% | PVT | 132+108.267 | 5.55 | 0.20% | Circular | VC57 | 179.643 | CNGR - KTM | -177000.000 |
| 115 | PVT | 132+108.267 | 5.55 | 0.20% | PVC | 134+357.448 | 10.01 | 0.20% | Linear | | 2249.181 | CNGR - KTM | |
| 116 | PVC | 134+357.448 | 10.01 | 0.20% | PVT | 134+466.473 | 10.12 | 0.00% | Circular | VC58 | 109.025 | CNGR - KTM | 55000.000 |
| 117 | PVT | 134+466.473 | 10.12 | 0.00% | PVC | 137+579.272 | 10.12 | 0.00% | Linear | | 3112.799 | KTM - EKM | |
| 118 | PVC | 137+579.272 | 10.12 | 0.00% | PVT | 137+691.247 | 9.99 | -0.22% | Circular | VC59 | 111.975 | KTM - EKM | 50000.000 |
| 119 | PVT | 137+691.247 | 9.99 | -0.22% | PVC | 139+133.350 | 6.76 | -0.22% | Linear | | 1442.104 | KTM - EKM | |
| 120 | PVC | 139+133.350 | 6.76 | -0.22% | PVT | 139+306.707 | 6.75 | 0.21% | Circular | VC60 | 173.357 | KTM - EKM | -40000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 121 | PVT | 139+306.707 | 6.75 | 0.21% | PVC | 140+406.102 | 9.05 | 0.21% | Linear | | 1099.395 | KTM - EKM | |
| 122 | PVC | 140+406.102 | 9.05 | 0.21% | PVT | 140+501.419 | 9.48 | 0.69% | Circular | VC61 | 95.317 | KTM - EKM | -20000.000 |
| 123 | PVT | 140+501.419 | 9.48 | 0.69% | PVC | 142+070.470 | 20.25 | 0.69% | Linear | | 1569.051 | KTM - EKM | |
| 124 | PVC | 142+070.470 | 20.25 | 0.69% | PVT | 142+241.338 | 20.61 | -0.26% | Circular | VC62 | 170.869 | KTM - EKM | 18000.000 |
| 125 | PVT | 142+241.338 | 20.61 | -0.26% | PVC | 144+474.243 | 14.73 | -0.26% | Linear | | 2232.904 | KTM - EKM | |
| 126 | PVC | 144+474.243 | 14.73 | -0.26% | PVT | 144+589.612 | 14.5 | -0.14% | Circular | VC63 | 115.369 | KTM - EKM | -90000.000 |
| 127 | PVT | 144+589.612 | 14.5 | -0.14% | PVC | 146+202.593 | 12.32 | -0.14% | Linear | | 1612.981 | KTM - EKM | |
| 128 | PVC | 146+202.593 | 12.32 | -0.14% | PVT | 146+406.894 | 13.2 | 1.00% | Circular | VC64 | 204.301 | KTM - EKM | -18000.000 |
| 129 | PVT | 146+406.894 | 13.2 | 1.00% | PVC | 147+917.927 | 28.31 | 1.00% | Linear | | 1511.033 | KTM - EKM | |
| 130 | PVC | 147+917.927 | 28.31 | 1.00% | PVT | 148+073.915 | 29.41 | 0.40% | Circular | VC65 | 155.988 | KTM - EKM | 26000.000 |
| 131 | PVT | 148+073.915 | 29.41 | 0.40% | PVC | 149+058.854 | 33.35 | 0.40% | Linear | | 984.939 | KTM - EKM | |
| 132 | PVC | 149+058.854 | 33.35 | 0.40% | PVT | 149+220.834 | 34.72 | 1.30% | Circular | VC66 | 161.981 | KTM - EKM | -18000.000 |
| 133 | PVT | 149+220.834 | 34.72 | 1.30% | PVC | 150+583.296 | 52.44 | 1.30% | Linear | | 1362.461 | KTM - EKM | |
| 134 | PVC | 150+583.296 | 52.44 | 1.30% | PVT | 151+063.261 | 52.92 | -1.10% | Circular | VC67 | 479.965 | KTM - EKM | 20000.000 |
| 135 | PVT | 151+063.261 | 52.92 | -1.10% | PVC | 152+372.467 | 38.51 | -1.10% | Linear | | 1309.207 | KTM - EKM | |
| 136 | PVC | 152+372.467 | 38.51 | -1.10% | PVT | 152+554.451 | 37.15 | -0.40% | Circular | VC68 | 181.984 | KTM - EKM | -26000.000 |
| 137 | PVT | 152+554.451 | 37.15 | -0.40% | PVC | 155+294.518 | 26.19 | -0.40% | Linear | | 2740.068 | KTM - EKM | |
| 138 | PVC | 155+294.518 | 26.19 | -0.40% | PVT | 155+569.382 | 27.19 | 1.13% | Circular | VC69 | 274.864 | KTM - EKM | -18000.000 |
| 139 | PVT | 155+569.382 | 27.19 | 1.13% | PVC | 156+872.689 | 41.88 | 1.13% | Linear | | 1303.307 | KTM - EKM | |
| 140 | PVC | 156+872.689 | 41.88 | 1.13% | PVT | 157+350.527 | 41.55 | -1.26% | Circular | VC70 | 477.838 | KTM - EKM | 20000.000 |
| 141 | PVT | 157+350.527 | 41.55 | -1.26% | PVC | 159+316.402 | 16.74 | -1.26% | Linear | | 1965.875 | KTM - EKM | |
| 142 | PVC | 159+316.402 | 16.74 | -1.26% | PVT | 159+478.941 | 15.35 | -0.45% | Circular | VC71 | 162.539 | KTM - EKM | -20000.000 |
| 143 | PVT | 159+478.941 | 15.35 | -0.45% | PVC | 160+613.195 | 10.25 | -0.45% | Linear | | 1134.254 | KTM - EKM | |
| 144 | PVC | 160+613.195 | 10.25 | -0.45% | PVT | 160+729.447 | 10.1 | 0.20% | Circular | VC72 | 116.252 | KTM - EKM | -18000.000 |
| 145 | PVT | 160+729.447 | 10.1 | 0.20% | PVC | 162+176.894 | 12.95 | 0.20% | Linear | | 1447.447 | KTM - EKM | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 146 | PVC | 162+176.894 | 12.95 | 0.20% | PVT | 162+429.510 | 15.21 | 1.60% | Circular | VC73 | 252.616 | KTM - EKM | -18000.000 |
| 147 | PVT | 162+429.510 | 15.21 | 1.60% | PVC | 163+836.954 | 37.73 | 1.60% | Linear | | 1407.444 | KTM - EKM | |
| 148 | PVC | 163+836.954 | 37.73 | 1.60% | PVT | 164+412.880 | 37.73 | -1.60% | Circular | VC74 | 575.926 | KTM - EKM | 18000.000 |
| 149 | PVT | 164+412.880 | 37.73 | -1.60% | PVC | 166+026.017 | 11.92 | -1.60% | Linear | | 1613.137 | KTM - EKM | |
| 150 | PVC | 166+026.017 | 11.92 | -1.60% | PVT | 166+288.554 | 9.64 | -0.14% | Circular | VC75 | 262.538 | KTM - EKM | -18000.000 |
| 151 | PVT | 166+288.554 | 9.64 | -0.14% | PVC | 168+722.468 | 6.2 | -0.14% | Linear | | 2433.914 | KTM - EKM | |
| 152 | PVC | 168+722.468 | 6.2 | -0.14% | PVT | 168+840.733 | 6.34 | 0.37% | Circular | VC76 | 118.266 | KTM - EKM | -23000.000 |
| 153 | PVT | 168+840.733 | 6.34 | 0.37% | PVC | 170+023.752 | 10.75 | 0.37% | Linear | | 1183.019 | KTM - EKM | |
| 154 | PVC | 170+023.752 | 10.75 | 0.37% | PVT | 170+143.495 | 10.9 | -0.13% | Circular | VC77 | 119.743 | KTM - EKM | 24000.000 |
| 155 | PVT | 170+143.495 | 10.9 | -0.13% | PVC | 172+150.033 | 8.37 | -0.13% | Linear | | 2006.538 | KTM - EKM | |
| 156 | PVC | 172+150.033 | 8.37 | -0.13% | PVT | 172+457.959 | 8.68 | 0.33% | Circular | VC78 | 307.927 | KTM - EKM | -68000.000 |
| 157 | PVT | 172+457.959 | 8.68 | 0.33% | PVC | 174+173.315 | 14.29 | 0.33% | Linear | | 1715.355 | KTM - EKM | |
| 158 | PVC | 174+173.315 | 14.29 | 0.33% | PVT | 174+287.458 | 14.44 | -0.05% | Circular | VC79 | 114.143 | KTM - EKM | 30000.000 |
| 159 | PVT | 174+287.458 | 14.44 | -0.05% | PVC | 176+984.109 | 12.99 | -0.05% | Linear | | 2696.651 | KTM - EKM | |
| 160 | PVC | 176+984.109 | 12.99 | -0.05% | PVT | 177+209.205 | 12.75 | -0.17% | Circular | VC80 | 225.097 | KTM - EKM | 200000.000 |
| 161 | PVT | 177+209.205 | 12.75 | -0.17% | PVC | 178+131.173 | 11.22 | -0.17% | Linear | | 921.967 | KTM - EKM | |
| 162 | PVC | 178+131.173 | 11.22 | -0.17% | PVT | 178+449.048 | 13.49 | 1.60% | Circular | VC81 | 317.875 | KTM - EKM | -18000.000 |
| 163 | PVT | 178+449.048 | 13.49 | 1.60% | PVC | 179+847.109 | 35.86 | 1.60% | Linear | | 1398.061 | KTM - EKM | |
| 164 | PVC | 179+847.109 | 35.86 | 1.60% | PVT | 180+351.057 | 36.87 | -1.20% | Circular | VC82 | 503.948 | KTM - EKM | 18000.000 |
| 165 | PVT | 180+351.057 | 36.87 | -1.20% | PVC | 181+852.732 | 18.85 | -1.20% | Linear | | 1501.675 | KTM - EKM | |
| 166 | PVC | 181+852.732 | 18.85 | -1.20% | PVT | 182+036.983 | 17.18 | -0.62% | Circular | VC83 | 184.251 | KTM - EKM | -31500.000 |
| 167 | PVT | 182+036.983 | 17.18 | -0.62% | PVC | 183+843.700 | 6.07 | -0.62% | Linear | | 1806.717 | KTM - EKM | |
| 168 | PVC | 183+843.700 | 6.07 | -0.62% | PVT | 183+957.313 | 5.73 | 0.02% | Circular | VC84 | 113.613 | KTM - EKM | -18000.000 |
| 169 | PVT | 183+957.313 | 5.73 | 0.02% | PVC | 185+240.307 | 5.93 | 0.02% | Linear | | 1282.995 | KTM - EKM | |
| 170 | PVC | 185+240.307 | 5.93 | 0.02% | PVT | 185+345.979 | 5.94 | -0.01% | Circular | VC85 | 105.671 | KTM - EKM | 387500.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 171 | PVT | 185+345.979 | 5.94 | -0.01% | PVC | 188+850.710 | 5.55 | -0.01% | Linear | | 3504.731 | KTM - EKM | |
| 172 | PVC | 188+850.710 | 5.55 | -0.01% | PVT | 188+983.822 | 6.03 | 0.73% | Circular | VC86 | 133.113 | KTM - EKM | -18000.000 |
| 173 | PVT | 188+983.822 | 6.03 | 0.73% | PVC | 189+873.101 | 12.5 | 0.73% | Linear | | 889.278 | KTM - EKM | |
| 174 | PVC | 189+873.101 | 12.5 | 0.73% | PVT | 190+004.109 | 12.98 | 0.00% | Circular | VC87 | 131.009 | KTM - EKM | 18000.000 |
| 175 | PVT | 190+004.109 | 12.98 | 0.00% | PVC | 196+695.640 | 13.02 | 0.00% | Linear | | 6691.531 | EKM - KOA | |
| 176 | PVC | 196+695.640 | 13.02 | 0.00% | PVT | 196+985.222 | 12.19 | -0.58% | Circular | VC88 | 289.582 | EKM - KOA | 50000.000 |
| 177 | PVT | 196+985.222 | 12.19 | -0.58% | PVC | 198+104.515 | 5.71 | -0.58% | Linear | | 1119.293 | EKM - KOA | |
| 178 | PVC | 198+104.515 | 5.71 | -0.58% | PVT | 198+208.654 | 5.41 | 0.00% | Circular | VC89 | 104.139 | EKM - KOA | -18000.000 |
| 179 | PVT | 198+208.654 | 5.41 | 0.00% | PVC | 199+829.794 | 5.41 | 0.00% | Linear | | 1621.140 | EKM - KOA | |
| 180 | PVC | 199+829.794 | 5.41 | 0.00% | PVT | 200+090.289 | 7.29 | 1.45% | Circular | VC90 | 260.495 | EKM - KOA | -18000.000 |
| 181 | PVT | 200+090.289 | 7.29 | 1.45% | PVC | 201+092.364 | 21.8 | 1.45% | Linear | | 1002.075 | EKM - KOA | |
| 182 | PVC | 201+092.364 | 21.8 | 1.45% | PVT | 201+497.633 | 23.1 | -0.80% | Circular | VC91 | 405.269 | EKM - KOA | 18000.000 |
| 183 | PVT | 201+497.633 | 23.1 | -0.80% | PVC | 202+426.084 | 15.63 | -0.80% | Linear | | 928.451 | EKM - KOA | |
| 184 | PVC | 202+426.084 | 15.63 | -0.80% | PVT | 202+708.206 | 15.57 | 0.76% | Circular | VC92 | 282.122 | EKM - KOA | -18000.000 |
| 185 | PVT | 202+708.206 | 15.57 | 0.76% | PVC | 203+998.739 | 25.42 | 0.76% | Linear | | 1290.533 | EKM - KOA | |
| 186 | PVC | 203+998.739 | 25.42 | 0.76% | PVT | 204+242.499 | 25.63 | -0.59% | Circular | VC93 | 243.760 | EKM - KOA | 18000.000 |
| 187 | PVT | 204+242.499 | 25.63 | -0.59% | PVC | 205+457.392 | 18.45 | -0.59% | Linear | | 1214.894 | EKM - KOA | |
| 188 | PVC | 205+457.392 | 18.45 | -0.59% | PVT | 205+560.622 | 18.11 | -0.08% | Circular | VC94 | 103.230 | EKM - KOA | -20000.000 |
| 189 | PVT | 205+560.622 | 18.11 | -0.08% | PVC | 209+218.201 | 15.36 | -0.08% | Linear | | 3657.578 | EKM - KOA | |
| 190 | PVC | 209+218.201 | 15.36 | -0.08% | PVT | 209+321.034 | 15.18 | -0.28% | Circular | VC95 | 102.834 | EKM - KOA | 50000.000 |
| 191 | PVT | 209+321.034 | 15.18 | -0.28% | PVC | 211+029.470 | 10.38 | -0.28% | Linear | | 1708.436 | EKM - KOA | |
| 192 | PVC | 211+029.470 | 10.38 | -0.28% | PVT | 211+169.815 | 10.19 | 0.00% | Circular | VC96 | 140.345 | EKM - KOA | -50000.000 |
| 193 | PVT | 211+169.815 | 10.19 | 0.00% | PVC | 212+919.025 | 10.19 | 0.00% | Linear | | 1749.209 | KOA - TSR | |
| 194 | PVC | 212+919.025 | 10.19 | 0.00% | PVT | 213+189.267 | 12.27 | 1.54% | Circular | VC97 | 270.242 | KOA - TSR | -17500.000 |
| 195 | PVT | 213+189.267 | 12.27 | 1.54% | PVC | 213+848.198 | 22.45 | 1.54% | Linear | | 658.931 | KOA - TSR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 196 | PVC | 213+848.198 | 22.45 | 1.54% | PVT | 214+118.440 | 24.54 | 0.00% | Circular | VC98 | 270.242 | KOA - TSR | 17500.000 |
| 197 | PVT | 214+118.440 | 24.54 | 0.00% | PVC | 215+157.633 | 24.54 | 0.00% | Linear | | 1039.193 | KOA - TSR | |
| 198 | PVC | 215+157.633 | 24.54 | 0.00% | PVT | 215+277.072 | 24.13 | -0.68% | Circular | VC99 | 119.440 | KOA - TSR | 17500.000 |
| 199 | PVT | 215+277.072 | 24.13 | -0.68% | PVC | 216+930.986 | 12.84 | -0.68% | Linear | | 1653.914 | KOA - TSR | |
| 200 | PVC | 216+930.986 | 12.84 | -0.68% | PVT | 217+107.918 | 12.5 | 0.30% | Circular | VC100 | 176.931 | KOA - TSR | -18000.000 |
| 201 | PVT | 217+107.918 | 12.5 | 0.30% | PVC | 219+728.238 | 20.38 | 0.30% | Linear | | 2620.320 | KOA - TSR | |
| 202 | PVC | 219+728.238 | 20.38 | 0.30% | PVT | 219+859.915 | 20.66 | 0.12% | Circular | VC101 | 131.677 | KOA - TSR | 75000.000 |
| 203 | PVT | 219+859.915 | 20.66 | 0.12% | PVC | 221+095.614 | 22.2 | 0.12% | Linear | | 1235.700 | KOA - TSR | |
| 204 | PVC | 221+095.614 | 22.2 | 0.12% | PVT | 221+243.122 | 21.84 | -0.61% | Circular | VC102 | 147.508 | KOA - TSR | 20000.000 |
| 205 | PVT | 221+243.122 | 21.84 | -0.61% | PVC | 223+150.314 | 10.15 | -0.61% | Linear | | 1907.192 | KOA - TSR | |
| 206 | PVC | 223+150.314 | 10.15 | -0.61% | PVT | 223+322.430 | 9.84 | 0.25% | Circular | VC103 | 172.116 | KOA - TSR | -20000.000 |
| 207 | PVT | 223+322.430 | 9.84 | 0.25% | PVC | 225+223.616 | 14.55 | 0.25% | Linear | | 1901.186 | KOA - TSR | |
| 208 | PVC | 225+223.616 | 14.55 | 0.25% | PVT | 225+374.031 | 14.75 | 0.02% | Circular | VC104 | 150.415 | KOA - TSR | 65000.000 |
| 209 | PVT | 225+374.031 | 14.75 | 0.02% | PVC | 228+888.513 | 15.33 | 0.02% | Linear | | 3514.482 | KOA - TSR | |
| 210 | PVC | 228+888.513 | 15.33 | 0.02% | PVT | 228+972.094 | 15.21 | -0.32% | Circular | VC105 | 83.580 | KOA - TSR | 25000.000 |
| 211 | PVT | 228+972.094 | 15.21 | -0.32% | PVC | 230+041.043 | 11.81 | -0.32% | Linear | | 1068.949 | KOA - TSR | |
| 212 | PVC | 230+041.043 | 11.81 | -0.32% | PVT | 230+196.769 | 11.92 | 0.46% | Circular | VC106 | 155.727 | KOA - TSR | -20000.000 |
| 213 | PVT | 230+196.769 | 11.92 | 0.46% | PVC | 231+210.981 | 16.59 | 0.46% | Linear | | 1014.212 | KOA - TSR | |
| 214 | PVC | 231+210.981 | 16.59 | 0.46% | PVT | 231+258.086 | 16.75 | 0.20% | Circular | VC107 | 47.105 | KOA - TSR | 40000.000 |
| 215 | PVT | 231+258.086 | 16.75 | 0.20% | PVC | 233+493.057 | 21.2 | 0.20% | Linear | | 2234.971 | KOA - TSR | |
| 216 | PVC | 233+493.057 | 21.2 | 0.20% | PVT | 233+605.637 | 21.07 | -0.43% | Circular | VC108 | 112.580 | KOA - TSR | 18000.000 |
| 217 | PVT | 233+605.637 | 21.07 | -0.43% | PVC | 236+973.233 | 6.71 | -0.43% | Linear | | 3367.596 | KOA - TSR | |
| 218 | PVC | 236+973.233 | 6.71 | -0.43% | PVT | 237+079.813 | 6.49 | 0.00% | Circular | VC109 | 106.580 | KOA - TSR | -25000.000 |
| 219 | PVT | 237+079.813 | 6.49 | 0.00% | PVC | 242+403.332 | 6.49 | 0.00% | Linear | | 5323.519 | KOA - TSR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 220 | PVC | 242+403.332 | 6.49 | 0.00% | PVT | 242+487.085 | 6.51 | 0.04% | Circular | VC110 | 83.753 | KOA - TSR | -200000.000 |
| 221 | PVT | 242+487.085 | 6.51 | 0.04% | PVC | 245+966.197 | 7.96 | 0.04% | Linear | | 3479.112 | KOA - TSR | |
| 222 | PVC | 245+966.197 | 7.96 | 0.04% | PVT | 246+117.017 | 8.21 | 0.29% | Circular | VC111 | 150.820 | KOA - TSR | -60000.000 |
| 223 | PVT | 246+117.017 | 8.21 | 0.29% | PVC | 247+504.478 | 12.28 | 0.29% | Linear | | 1387.461 | KOA - TSR | |
| 224 | PVC | 247+504.478 | 12.28 | 0.29% | PVT | 247+624.798 | 12.27 | -0.31% | Circular | VC112 | 120.321 | KOA - TSR | 20000.000 |
| 225 | PVT | 247+624.798 | 12.27 | -0.31% | PVC | 250+004.028 | 4.94 | -0.31% | Linear | | 2379.229 | KOA - TSR | |
| 226 | PVC | 250+004.028 | 4.94 | -0.31% | PVT | 250+139.870 | 4.98 | 0.37% | Circular | VC113 | 135.842 | KOA - TSR | -20000.000 |
| 227 | PVT | 250+139.870 | 4.98 | 0.37% | PVC | 250+957.308 | 8.01 | 0.37% | Linear | | 817.438 | KOA - TSR | |
| 228 | PVC | 250+957.308 | 8.01 | 0.37% | PVT | 251+096.092 | 8.85 | 0.83% | Circular | VC114 | 138.784 | KOA - TSR | -30000.000 |
| 229 | PVT | 251+096.092 | 8.85 | 0.83% | PVC | 251+750.169 | 14.3 | 0.83% | Linear | | 654.076 | KOA - TSR | |
| 230 | PVC | 251+750.169 | 14.3 | 0.83% | PVT | 251+989.861 | 14.7 | -0.50% | Circular | VC115 | 239.692 | KOA - TSR | 18000.000 |
| 231 | PVT | 251+989.861 | 14.7 | -0.50% | PVC | 253+505.135 | 7.15 | -0.50% | Linear | | 1515.274 | KOA - TSR | |
| 232 | PVC | 253+505.135 | 7.15 | -0.50% | PVT | 253+604.767 | 6.9 | 0.00% | Circular | VC116 | 99.632 | KOA - TSR | -20000.000 |
| 233 | PVT | 253+604.767 | 6.9 | 0.00% | PVC | 255+865.233 | 6.9 | 0.00% | Linear | | 2260.466 | KOA - TSR | |
| 234 | PVC | 255+865.233 | 6.9 | 0.00% | PVT | 256+058.861 | 7.95 | 1.08% | Circular | VC117 | 193.628 | KOA - TSR | -18000.000 |
| 235 | PVT | 256+058.861 | 7.95 | 1.08% | PVC | 257+774.679 | 26.4 | 1.08% | Linear | | 1715.819 | KOA - TSR | |
| 236 | PVC | 257+774.679 | 26.4 | 1.08% | PVT | 257+968.307 | 27.45 | 0.00% | Circular | VC118 | 193.628 | KOA - TSR | 18000.000 |
| 237 | PVT | 257+968.307 | 27.45 | 0.00% | PVC | 260+196.097 | 27.45 | 0.00% | Linear | | 2227.790 | TSR - TIR | |
| 238 | PVC | 260+196.097 | 27.45 | 0.00% | PVT | 260+300.985 | 27.38 | -0.13% | Circular | VC119 | 104.888 | TSR - TIR | 80000.000 |
| 239 | PVT | 260+300.985 | 27.38 | -0.13% | PVC | 262+174.200 | 24.92 | -0.13% | Linear | | 1873.215 | TSR - TIR | |
| 240 | PVC | 262+174.200 | 24.92 | -0.13% | PVT | 262+320.862 | 24.13 | -0.95% | Circular | VC120 | 146.663 | TSR - TIR | 18000.000 |
| 241 | PVT | 262+320.862 | 24.13 | -0.95% | PVC | 263+904.605 | 9.15 | -0.95% | Linear | | 1583.743 | TSR - TIR | |
| 242 | PVC | 263+904.605 | 9.15 | -0.95% | PVT | 264+172.155 | 8.61 | 0.54% | Circular | VC121 | 267.550 | TSR - TIR | -18000.000 |
| 243 | PVT | 264+172.155 | 8.61 | 0.54% | PVC | 265+448.365 | 15.51 | 0.54% | Linear | | 1276.210 | TSR - TIR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 244 | PVC | 265+448.365 | 15.51 | 0.54% | PVT | 265+580.522 | 15.73 | -0.19% | Circular | VC122 | 132.157 | TSR - TIR | 18000.000 |
| 245 | PVT | 265+580.522 | 15.73 | -0.19% | PVC | 267+808.080 | 11.42 | -0.19% | Linear | | 2227.558 | TSR - TIR | |
| 246 | PVC | 267+808.080 | 11.42 | -0.19% | PVT | 267+904.941 | 11.33 | 0.00% | Circular | VC123 | 96.860 | TSR - TIR | -50000.000 |
| 247 | PVT | 267+904.941 | 11.33 | 0.00% | PVC | 270+330.496 | 11.33 | 0.00% | Linear | | 2425.555 | TSR - TIR | |
| 248 | PVC | 270+330.496 | 11.33 | 0.00% | PVT | 270+459.955 | 11.71 | 0.59% | Circular | VC124 | 129.459 | TSR - TIR | -22000.000 |
| 249 | PVT | 270+459.955 | 11.71 | 0.59% | PVC | 271+455.313 | 17.56 | 0.59% | Linear | | 995.358 | TSR - TIR | |
| 250 | PVC | 271+455.313 | 17.56 | 0.59% | PVT | 271+573.004 | 17.91 | 0.00% | Circular | VC125 | 117.690 | TSR - TIR | 20000.000 |
| 251 | PVT | 271+573.004 | 17.91 | 0.00% | PVC | 273+404.509 | 17.91 | 0.00% | Linear | | 1831.505 | TSR - TIR | |
| 252 | PVC | 273+404.509 | 17.91 | 0.00% | PVT | 273+511.505 | 18.1 | 0.36% | Circular | VC126 | 106.997 | TSR - TIR | -30000.000 |
| 253 | PVT | 273+511.505 | 18.1 | 0.36% | PVC | 275+915.465 | 26.67 | 0.36% | Linear | | 2403.959 | TSR - TIR | |
| 254 | PVC | 275+915.465 | 26.67 | 0.36% | PVT | 276+218.532 | 25.2 | -1.33% | Circular | VC127 | 303.067 | TSR - TIR | 18000.000 |
| 255 | PVT | 276+218.532 | 25.2 | -1.33% | PVC | 277+128.472 | 13.13 | -1.33% | Linear | | 909.940 | TSR - TIR | |
| 256 | PVC | 277+128.472 | 13.13 | -1.33% | PVT | 277+338.017 | 11.6 | -0.13% | Circular | VC128 | 209.546 | TSR - TIR | -17500.000 |
| 257 | PVT | 277+338.017 | 11.6 | -0.13% | PVC | 279+206.108 | 9.18 | -0.13% | Linear | | 1868.091 | TSR - TIR | |
| 258 | PVC | 279+206.108 | 9.18 | -0.13% | PVT | 279+326.313 | 9.12 | 0.03% | Circular | VC129 | 120.205 | TSR - TIR | -75000.000 |
| 259 | PVT | 279+326.313 | 9.12 | 0.03% | PVC | 281+912.951 | 9.91 | 0.03% | Linear | | 2586.639 | TSR - TIR | |
| 260 | PVC | 281+912.951 | 9.91 | 0.03% | PVT | 282+081.737 | 9.73 | -0.25% | Circular | VC130 | 168.786 | TSR - TIR | 60000.000 |
| 261 | PVT | 282+081.737 | 9.73 | -0.25% | PVC | 283+318.316 | 6.63 | -0.25% | Linear | | 1236.580 | TSR - TIR | |
| 262 | PVC | 283+318.316 | 6.63 | -0.25% | PVT | 283+511.753 | 7.18 | 0.82% | Circular | VC131 | 193.437 | TSR - TIR | -18000.000 |
| 263 | PVT | 283+511.753 | 7.18 | 0.82% | PVC | 284+662.228 | 16.66 | 0.82% | Linear | | 1150.475 | TSR - TIR | |
| 264 | PVC | 284+662.228 | 16.66 | 0.82% | PVT | 284+937.601 | 16.82 | -0.71% | Circular | VC132 | 275.373 | TSR - TIR | 18000.000 |
| 265 | PVT | 284+937.601 | 16.82 | -0.71% | PVC | 286+122.533 | 8.46 | -0.71% | Linear | | 1184.932 | TSR - TIR | |
| 266 | PVC | 286+122.533 | 8.46 | -0.71% | PVT | 286+289.292 | 8.05 | 0.22% | Circular | VC133 | 166.758 | TSR - TIR | -18000.000 |
| 267 | PVT | 286+289.292 | 8.05 | 0.22% | PVC | 287+355.497 | 10.41 | 0.22% | Linear | | 1066.205 | TSR - TIR | |
| 268 | PVC | 287+355.497 | 10.41 | 0.22% | PVT | 287+487.828 | 10.55 | 0.00% | Circular | VC134 | 132.331 | TSR - TIR | 60000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 269 | PVT | 287+487.828 | 10.55 | 0.00% | PVC | 288+705.579 | 10.55 | 0.00% | Linear | | 1217.751 | TSR - TIR | |
| 270 | PVC | 288+705.579 | 10.55 | 0.00% | PVT | 288+813.978 | 10.43 | -0.22% | Circular | VC135 | 108.399 | TSR - TIR | 50000.000 |
| 271 | PVT | 288+813.978 | 10.43 | -0.22% | PVC | 291+098.981 | 5.48 | -0.22% | Linear | | 2285.003 | TSR - TIR | |
| 272 | PVC | 291+098.981 | 5.48 | -0.22% | PVT | 291+250.739 | 5.32 | 0.00% | Circular | VC136 | 151.758 | TSR - TIR | -70000.000 |
| 273 | PVT | 291+250.739 | 5.32 | 0.00% | PVC | 292+186.623 | 5.32 | 0.00% | Linear | | 935.884 | TSR - TIR | |
| 274 | PVC | 292+186.623 | 5.32 | 0.00% | PVT | 292+395.291 | 6.4 | 1.04% | Circular | VC137 | 208.668 | TSR - TIR | -20000.000 |
| 275 | PVT | 292+395.291 | 6.4 | 1.04% | PVC | 293+113.065 | 13.89 | 1.04% | Linear | | 717.774 | TSR - TIR | |
| 276 | PVC | 293+113.065 | 13.89 | 1.04% | PVT | 293+405.516 | 14.57 | -0.58% | Circular | VC138 | 292.450 | TSR - TIR | 18000.000 |
| 277 | PVT | 293+405.516 | 14.57 | -0.58% | PVC | 294+414.104 | 8.71 | -0.58% | Linear | | 1008.588 | TSR - TIR | |
| 278 | PVC | 294+414.104 | 8.71 | -0.58% | PVT | 294+540.747 | 8.37 | 0.05% | Circular | VC139 | 126.644 | TSR - TIR | -20000.000 |
| 279 | PVT | 294+540.747 | 8.37 | 0.05% | PVC | 296+844.414 | 9.56 | 0.05% | Linear | | 2303.667 | TSR - TIR | |
| 280 | PVC | 296+844.414 | 9.56 | 0.05% | PVT | 296+948.064 | 9.59 | 0.00% | Circular | VC140 | 103.650 | TSR - TIR | 200000.000 |
| 281 | PVT | 296+948.064 | 9.59 | 0.00% | PVC | 300+874.084 | 9.59 | 0.00% | Linear | | 3926.020 | TSR - TIR | |
| 282 | PVC | 300+874.084 | 9.59 | 0.00% | PVT | 300+985.160 | 9.67 | 0.15% | Circular | VC141 | 111.075 | TSR - TIR | -75000.000 |
| 283 | PVT | 300+985.160 | 9.67 | 0.15% | PVC | 304+730.293 | 15.22 | 0.15% | Linear | | 3745.134 | TSR - TIR | |
| 284 | PVC | 304+730.293 | 15.22 | 0.15% | PVT | 304+834.600 | 15.25 | -0.08% | Circular | VC142 | 104.307 | TSR - TIR | 45000.000 |
| 285 | PVT | 304+834.600 | 15.25 | -0.08% | PVC | 306+308.033 | 14.02 | -0.08% | Linear | | 1473.433 | TSR - TIR | |
| 286 | PVC | 306+308.033 | 14.02 | -0.08% | PVT | 306+454.346 | 14.04 | 0.11% | Circular | VC143 | 146.313 | TSR - TIR | -75000.000 |
| 287 | PVT | 306+454.346 | 14.04 | 0.11% | PVC | 307+791.683 | 15.53 | 0.11% | Linear | | 1337.337 | TSR - TIR | |
| 288 | PVC | 307+791.683 | 15.53 | 0.11% | PVT | 307+903.295 | 15.34 | -0.45% | Circular | VC144 | 111.612 | TSR - TIR | 20000.000 |
| 289 | PVT | 307+903.295 | 15.34 | -0.45% | PVC | 309+500.914 | 8.21 | -0.45% | Linear | | 1597.619 | TSR - TIR | |
| 290 | PVC | 309+500.914 | 8.21 | -0.45% | PVT | 309+608.889 | 8.02 | 0.09% | Circular | VC145 | 107.974 | TSR - TIR | -20000.000 |
| 291 | PVT | 309+608.889 | 8.02 | 0.09% | PVC | 310+876.406 | 9.2 | 0.09% | Linear | | 1267.517 | TSR - TIR | |
| 292 | PVC | 310+876.406 | 9.2 | 0.09% | PVT | 310+984.617 | 9.2 | -0.09% | Circular | VC146 | 108.212 | TSR - TIR | 60000.000 |
| 293 | PVT | 310+984.617 | 9.2 | -0.09% | PVC | 315+046.912 | 5.66 | -0.09% | Linear | | 4062.295 | TSR - TIR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 294 | PVC | 315+046.912 | 5.66 | -0.09% | PVT | 315+157.545 | 5.62 | 0.01% | Circular | VC147 | 110.632 | TSR - TIR | -110000.000 |
| 295 | PVT | 315+157.545 | 5.62 | 0.01% | PVC | 316+893.742 | 5.85 | 0.01% | Linear | | 1736.197 | TSR - TIR | |
| 296 | PVC | 316+893.742 | 5.85 | 0.01% | PVT | 317+090.283 | 6.09 | 0.23% | Circular | VC148 | 196.541 | TSR - TIR | -90000.000 |
| 297 | PVT | 317+090.283 | 6.09 | 0.23% | PVC | 318+830.154 | 10.13 | 0.23% | Linear | | 1739.871 | TSR - TIR | |
| 298 | PVC | 318+830.154 | 10.13 | 0.23% | PVT | 318+969.239 | 10.29 | 0.00% | Circular | VC149 | 139.085 | TSR - TIR | 60000.000 |
| 299 | PVT | 318+969.239 | 10.29 | 0.00% | PVC | 322+707.120 | 10.29 | 0.00% | Linear | | 3737.881 | TIR - KKD | |
| 300 | PVC | 322+707.120 | 10.29 | 0.00% | PVT | 322+817.707 | 10.23 | -0.10% | Circular | VC150 | 110.588 | TIR - KKD | 110000.000 |
| 301 | PVT | 322+817.707 | 10.23 | -0.10% | PVC | 325+361.396 | 7.68 | -0.10% | Linear | | 2543.689 | TIR - KKD | |
| 302 | PVC | 325+361.396 | 7.68 | -0.10% | PVT | 325+508.532 | 7.66 | 0.08% | Circular | VC151 | 147.136 | TIR - KKD | -80000.000 |
| 303 | PVT | 325+508.532 | 7.66 | 0.08% | PVC | 327+690.072 | 9.48 | 0.08% | Linear | | 2181.540 | TIR - KKD | |
| 304 | PVC | 327+690.072 | 9.48 | 0.08% | PVT | 327+817.332 | 9.51 | -0.04% | Circular | VC152 | 127.260 | TIR - KKD | 100000.000 |
| 305 | PVT | 327+817.332 | 9.51 | -0.04% | PVC | 329+071.774 | 8.96 | -0.04% | Linear | | 1254.443 | TIR - KKD | |
| 306 | PVC | 329+071.774 | 8.96 | -0.04% | PVT | 329+171.254 | 9.01 | 0.16% | Circular | VC153 | 99.480 | TIR - KKD | -50000.000 |
| 307 | PVT | 329+171.254 | 9.01 | 0.16% | PVC | 331+256.008 | 12.25 | 0.16% | Linear | | 2084.754 | TIR - KKD | |
| 308 | PVC | 331+256.008 | 12.25 | 0.16% | PVT | 331+361.644 | 12.29 | -0.08% | Circular | VC154 | 105.636 | TIR - KKD | 45000.000 |
| 309 | PVT | 331+361.644 | 12.29 | -0.08% | PVC | 339+547.139 | 5.77 | -0.08% | Linear | | 8185.496 | TIR - KKD | |
| 310 | PVC | 339+547.139 | 5.77 | -0.08% | PVT | 339+694.512 | 5.71 | 0.00% | Circular | VC155 | 147.373 | TIR - KKD | -185000.000 |
| 311 | PVT | 339+694.512 | 5.71 | 0.00% | PVC | 343+166.069 | 5.71 | 0.00% | Linear | | 3471.558 | TIR - KKD | |
| 312 | PVC | 343+166.069 | 5.71 | 0.00% | PVT | 343+287.561 | 5.56 | -0.24% | Circular | VC156 | 121.492 | TIR - KKD | 50000.000 |
| 313 | PVT | 343+287.561 | 5.56 | -0.24% | PVC | 344+652.527 | 2.24 | -0.24% | Linear | | 1364.966 | TIR - KKD | |
| 314 | PVC | 344+652.527 | 2.24 | -0.24% | PVT | 344+743.197 | 2.19 | 0.12% | Circular | VC157 | 90.670 | TIR - KKD | -25000.000 |
| 315 | PVT | 344+743.197 | 2.19 | 0.12% | PVC | 348+210.891 | 6.34 | 0.12% | Linear | | 3467.694 | TIR - KKD | |
| 316 | PVC | 348+210.891 | 6.34 | 0.12% | PVT | 348+315.646 | 6.35 | -0.09% | Circular | VC158 | 104.755 | TIR - KKD | 50000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 317 | PVT | 348+315.646 | 6.35 | -0.09% | PVC | 350+526.071 | 4.37 | -0.09% | Linear | | 2210.426 | TIR - KKD | |
| 318 | PVC | 350+526.071 | 4.37 | -0.09% | PVT | 350+660.309 | 4.43 | 0.18% | Circular | VC159 | 134.237 | TIR - KKD | -50000.000 |
| 319 | PVT | 350+660.309 | 4.43 | 0.18% | PVC | 353+437.803 | 9.39 | 0.18% | Linear | | 2777.495 | TIR - KKD | |
| 320 | PVC | 353+437.803 | 9.39 | 0.18% | PVT | 353+754.034 | 7.18 | -1.58% | Circular | VC160 | 316.231 | TIR - KKD | 18000.000 |
| 321 | PVT | 353+754.034 | 7.18 | -1.58% | PVC | 355+893.616 | -26.59 | -1.58% | Linear | | 2139.582 | TIR - KKD | |
| 322 | PVC | 355+893.616 | -26.59 | -1.58% | PVT | 356+177.688 | -28.84 | 0.00% | Circular | VC161 | 284.072 | TIR - KKD | -18000.000 |
| 323 | PVT | 356+177.688 | -28.84 | 0.00% | PVC | 358+962.055 | -28.84 | 0.00% | Linear | | 2784.367 | KKD - KNR | |
| 324 | PVC | 358+962.055 | -28.84 | 0.00% | PVT | 359+238.314 | -26.72 | 1.53% | Circular | VC162 | 276.260 | KKD - KNR | -18000.000 |
| 325 | PVT | 359+238.314 | -26.72 | 1.53% | PVC | 361+361.878 | 5.88 | 1.53% | Linear | | 2123.564 | KKD - KNR | |
| 326 | PVC | 361+361.878 | 5.88 | 1.53% | PVT | 361+638.138 | 8 | 0.00% | Circular | VC163 | 276.260 | KKD - KNR | 18000.000 |
| 327 | PVT | 361+638.138 | 8 | 0.00% | PVC | 364+215.341 | 8 | 0.00% | Linear | | 2577.203 | KKD - KNR | |
| 328 | PVC | 364+215.341 | 8 | 0.00% | PVT | 364+348.048 | 8.25 | 0.38% | Circular | VC164 | 132.707 | KKD - KNR | -35000.000 |
| 329 | PVT | 364+348.048 | 8.25 | 0.38% | PVC | 365+334.030 | 11.99 | 0.38% | Linear | | 985.982 | KKD - KNR | |
| 330 | PVC | 365+334.030 | 11.99 | 0.38% | PVT | 365+473.621 | 11.98 | -0.40% | Circular | VC165 | 139.591 | KKD - KNR | 18000.000 |
| 331 | PVT | 365+473.621 | 11.98 | -0.40% | PVC | 366+615.443 | 7.45 | -0.40% | Linear | | 1141.822 | KKD - KNR | |
| 332 | PVC | 366+615.443 | 7.45 | -0.40% | PVT | 366+816.366 | 7.81 | 0.75% | Circular | VC166 | 200.923 | KKD - KNR | -17500.000 |
| 333 | PVT | 366+816.366 | 7.81 | 0.75% | PVC | 367+581.386 | 13.56 | 0.75% | Linear | | 765.020 | KKD - KNR | |
| 334 | PVC | 367+581.386 | 13.56 | 0.75% | PVT | 367+727.839 | 14.07 | -0.06% | Circular | VC167 | 146.453 | KKD - KNR | 18000.000 |
| 335 | PVT | 367+727.839 | 14.07 | -0.06% | PVC | 372+097.609 | 11.36 | -0.06% | Linear | | 4369.770 | KKD - KNR | |
| 336 | PVC | 372+097.609 | 11.36 | -0.06% | PVT | 372+197.657 | 11.02 | -0.62% | Circular | VC168 | 100.048 | KKD - KNR | 18000.000 |
| 337 | PVT | 372+197.657 | 11.02 | -0.62% | PVC | 373+323.296 | 4.07 | -0.62% | Linear | | 1125.639 | KKD - KNR | |
| 338 | PVC | 373+323.296 | 4.07 | -0.62% | PVT | 373+430.985 | 3.73 | -0.02% | Circular | VC169 | 107.690 | KKD - KNR | -18000.000 |
| 339 | PVT | 373+430.985 | 3.73 | -0.02% | PVC | 374+507.697 | 3.52 | -0.02% | Linear | | 1076.711 | KKD - KNR | |
| 340 | PVC | 374+507.697 | 3.52 | -0.02% | PVT | 374+607.974 | 3.74 | 0.46% | Circular | VC170 | 100.277 | KKD - KNR | -21000.000 |
| 341 | PVT | 374+607.974 | 3.74 | 0.46% | PVC | 375+609.713 | 8.33 | 0.46% | Linear | | 1001.739 | KKD - KNR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 342 | PVC | 375+609.713 | 8.33 | 0.46% | PVT | 375+801.432 | 8.19 | -0.61% | Circular | VC171 | 191.720 | KKD - KNR | 18000.000 |
| 343 | PVT | 375+801.432 | 8.19 | -0.61% | PVC | 376+531.363 | 3.76 | -0.61% | Linear | | 729.931 | KKD - KNR | |
| 344 | PVC | 376+531.363 | 3.76 | -0.61% | PVT | 376+643.930 | 3.42 | 0.02% | Circular | VC172 | 112.567 | KKD - KNR | -18000.000 |
| 345 | PVT | 376+643.930 | 3.42 | 0.02% | PVC | 377+372.665 | 3.56 | 0.02% | Linear | | 728.735 | KKD - KNR | |
| 346 | PVC | 377+372.665 | 3.56 | 0.02% | PVT | 377+481.718 | 3.78 | 0.38% | Circular | VC173 | 109.053 | KKD - KNR | -30000.000 |
| 347 | PVT | 377+481.718 | 3.78 | 0.38% | PVC | 378+136.655 | 6.28 | 0.38% | Linear | | 654.937 | KKD - KNR | |
| 348 | PVC | 378+136.655 | 6.28 | 0.38% | PVT | 378+254.942 | 6.57 | 0.12% | Circular | VC174 | 118.287 | KKD - KNR | 45000.000 |
| 349 | PVT | 378+254.942 | 6.57 | 0.12% | PVC | 379+613.721 | 8.19 | 0.12% | Linear | | 1358.780 | KKD - KNR | |
| 350 | PVC | 379+613.721 | 8.19 | 0.12% | PVT | 379+714.143 | 8.29 | 0.07% | Circular | VC175 | 100.421 | KKD - KNR | 220000.000 |
| 351 | PVT | 379+714.143 | 8.29 | 0.07% | PVC | 380+990.814 | 9.23 | 0.07% | Linear | | 1276.671 | KKD - KNR | |
| 352 | PVC | 380+990.814 | 9.23 | 0.07% | PVT | 381+102.993 | 9.26 | -0.01% | Circular | VC176 | 112.179 | KKD - KNR | 140000.000 |
| 353 | PVT | 381+102.993 | 9.26 | -0.01% | PVC | 382+314.126 | 9.18 | -0.01% | Linear | | 1211.134 | KKD - KNR | |
| 354 | PVC | 382+314.126 | 9.18 | -0.01% | PVT | 382+440.833 | 9.04 | -0.22% | Circular | VC177 | 126.707 | KKD - KNR | 60000.000 |
| 355 | PVT | 382+440.833 | 9.04 | -0.22% | PVC | 383+000 | 18.43 | -0.22% | Linear | | 560.000 | KKD - KNR | |
| 356 | PVT | 383+000 | 18.43 | 0.060% | PVT | 385+026 | 19.63 | 0.060% | Linear | | 2026.295 | KKD - KNR | |
| 357 | PVC | 385+026 | 19.63 | 0.060% | PVC | 385+142 | 19.67 | 0.002% | Circular | VC178 | 115.810 | KKD - KNR | 200000.000 |
| 358 | PVT | 385+142 | 19.67 | 0.002% | PVT | 389+451 | 19.74 | 0.002% | Linear | | 4310.430 | KKD - KNR | |
| 359 | PVC | 389+451 | 19.74 | 0.002% | PVC | 389+608 | 19.54 | -0.31% | Circular | VC179 | 156.420 | KKD - KNR | 50000.000 |
| 360 | PVT | 389+608 | 19.54 | -0.31% | PVT | 392+600 | 10.22 | -0.31% | Linear | | 2992.210 | KKD - KNR | |
| 361 | PVC | 392+600 | 10.22 | -0.31% | PVC | 392+745 | 10.04 | 0.05% | Circular | VC180 | 144.480 | KKD - KNR | 40000.000 |
| 362 | PVT | 392+745 | 10.04 | 0.05% | PVT | 397+943 | 12.64 | 0.05% | Linear | | 5198.850 | KKD - KNR | |
| 363 | PVC | 397+943 | 12.64 | 0.05% | PVC | 398+069 | 12.67 | 0.00% | Circular | VC181 | 126.000 | KKD - KNR | 250000.000 |
| 364 | PVT | 398+069 | 12.67 | 0.00% | PVT | 400+426 | 12.67 | 0.00% | Linear | | 2356.120 | KKD - KNR | |
| 365 | PVC | 400+426 | 12.67 | 0.00% | PVC | 400+538 | 12.63 | -0.112% | Circular | VC182 | 112.300 | KKD - KNR | 100000.000 |
| 366 | PVT | 400+538 | 12.63 | -0.112% | PVT | 401+668 | 11.3 | -0.112% | Linear | | 1130.310 | KKD - KNR | |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 367 | PVC | 401+668 | 11.3 | -0.112% | PVC | 401+837 | 11.25 | 0.000% | Circular | VC183 | 168.440 | KKD - KNR | 150000.000 |
| 368 | PVT | 401+837 | 11.25 | 0.00% | PVT | 402+614 | 11.25 | 0.000% | Linear | | 777.830 | KKD - KNR | |
| 369 | PVC | 402+614 | 11.25 | 0.00% | PVC | 402+796 | 12.2 | 1.013% | Circular | VC184 | 182.310 | KKD - KNR | 18000.000 |
| 370 | PVT | 402+796 | 12.2 | 1.013% | PVT | 404+154 | 25.35 | 1.013% | Linear | | 1358.060 | KKD - KNR | |
| 371 | PVC | 404+154 | 25.35 | 1.013% | PVC | 404+337 | 26.82 | 0.00% | Circular | VC185 | 182.370 | KKD - KNR | 18000.000 |
| 372 | PVT | 404+337 | 26.82 | 0.00% | PVT | 406+633 | 26.87 | 0.00% | Linear | | 2296.010 | KKD - KNR | |
| 373 | PVC | 406+633 | 26.87 | 0.00% | PVC | 406+756 | 27.01 | 0.274% | Circular | VC186 | 123.320 | KKD - KNR | 45000.000 |
| 374 | PVT | 406+756 | 27.01 | 0.274% | PVT | 407+928 | 30.18 | 0.274% | Linear | | 1172.250 | KKD - KNR | |
| 375 | PVC | 407+928 | 30.18 | 0.274% | PVC | 408+177 | 28.92 | -1.109% | Circular | VC187 | 248.940 | KKD - KNR | 18000.000 |
| 376 | PVT | 408+177 | 28.92 | -1.109% | PVT | 408+926 | 20.93 | -1.109% | Linear | | 748.400 | KKD - KNR | |
| 377 | PVC | 408+926 | 20.93 | -1.109% | PVC | 409+118 | 19.78 | -0.039% | Circular | VC188 | 192.070 | KKD - KNR | 18000.000 |
| 378 | PVT | 409+118 | 19.78 | -0.039% | PVT | 412+582 | 18.44 | -0.039% | Linear | | 3463.780 | KKD - KNR | |
| 379 | PVC | 412+582 | 18.44 | -0.039% | PVC | 412+718 | 18.32 | -0.107% | Circular | VC189 | 135.920 | KKD - KNR | 200000.000 |
| 380 | PVT | 412+718 | 18.32 | -0.107% | PVT | 416+256 | 14.56 | -0.107% | Linear | | 3537.730 | KKD - KNR | |
| 381 | PVC | 416+256 | 14.56 | -0.107% | PVC | 416+362 | 14.50 | 0.00% | Circular | VC190 | 106.750 | KKD - KNR | 100000.000 |
| 382 | PVT | 416+362 | 14.50 | 0.00% | PVT | 417+837 | 14.50 | 0.00% | Linear | | 1474.970 | KKD - KNR | |
| 383 | PVC | 417+837 | 14.50 | 0.00% | PVC | 417+963 | 14.82 | 0.419% | Circular | VC191 | 125.740 | KKD - KNR | 30000.000 |
| 384 | PVT | 417+963 | 14.82 | 0.419% | PVT | 420+260 | 24.43 | 0.419% | Linear | | 2297.150 | KKD - KNR | |
| 385 | PVC | 420+260 | 24.43 | 0.419% | PVC | 420+386 | 24.65 | 0.00% | Circular | VC192 | 125.740 | KKD - KNR | 30000.000 |
| 386 | PVT | 420+386 | 24.65 | 0.00% | PVT | 424+757 | 24.64 | 0.00% | Linear | | 4371.330 | KKD - KNR | |
| 387 | PVC | 424+757 | 24.64 | 0.00% | PVC | 424+950 | 24.52 | -0.643% | Circular | VC193 | 192.830 | KKD - KNR | 30000.000 |
| 388 | PVT | 424+950 | 24.52 | -0.643% | PVT | 426+148 | 16.36 | -0.643% | Linear | | 1197.690 | KKD - KNR | |
| 389 | PVC | 426+148 | 16.36 | -0.643% | PVC | 426+271 | 16.00 | 0.040% | Circular | VC194 | 122.910 | KKD - KNR | 18000.000 |
| 390 | PVT | 426+271 | 16.00 | 0.040% | PVT | 429+649 | 17.32 | 0.040% | Linear | | 3378.580 | KKD - KNR | |
| 391 | PVC | 429+649 | 17.32 | 0.040% | PVC | 429+750 | 17.33 | 0.000% | Circular | VC195 | 100.210 | KKD - KNR | 250000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 392 | PVT | 429+750 | 17.33 | 0.000% | PVT | 431+472 | 17.32 | 0.000% | Linear | | 1722.570 | KKD - KNR | |
| 393 | PVC | 431+472 | 17.32 | 0.000% | PVC | 431+800 | 16.94 | -0.637% | Circular | VC196 | 127.380 | KKD - KNR | 20000.000 |
| 394 | PVT | 431+800 | 16.94 | -0.637% | PVT | 432+490 | 11.20 | -0.637% | Linear | | 889.950 | KKD - KNR | |
| 395 | PVC | 432+490 | 11.20 | -0.637% | PVC | 432+610 | 10.87 | -0.035% | Circular | VC197 | 120.310 | KKD - KNR | 20000.000 |
| 396 | PVT | 432+610 | 10.87 | -0.035% | PVT | 433+835 | 10.45 | -0.035% | Linear | | 1225.520 | KKD - KNR | |
| 397 | PVC | 433+835 | 10.45 | -0.035% | PVC | 433+981 | 10.81 | 0.451% | Circular | VC198 | 146.030 | KKD - KNR | 30000.000 |
| 398 | PVT | 433+981 | 10.81 | 0.451% | PVT | 435+572 | 18.02 | 0.451% | Linear | | 1590.400 | KKD - KNR | |
| 399 | PVC | 435+572 | 18.02 | 0.451% | PVC | 435+693 | 18.16 | -0.035% | Circular | VC199 | 121.680 | KKD - KNR | 25000.000 |
| 400 | PVT | 435+693 | 18.16 | -0.035% | PVT | 443+351 | 18.14 | -0.035% | Linear | | 7658.000 | KKD - KNR | |
| 401 | PVC | 443+351 | 18.14 | -0.035% | PVT | 443+543 | 17.52 | -0.64% | Circular | VC200 | 191.546 | KKD - KNR | 30000.000 |
| 402 | PVT | 444+543 | 17.52 | -0.64% | PVC | 444+604 | 10.75 | -0.64% | Linear | | 1060.770 | KKD - KNR | |
| 403 | PVC | 444+604 | 10.75 | -0.64% | PVT | 444+859 | 9.94 | 0.00% | Circular | VC201 | 255.394 | KKD - KNR | -40000.000 |
| 404 | PVT | 444+859 | 9.94 | 0.00% | PVC | 448+458 | 9.94 | 0.00% | Linear | | 3599.366 | KNR - KGD | |
| 405 | PVC | 448+458 | 9.94 | 0.00% | PVT | 448+766 | 11.12 | 0.77% | Circular | VC202 | 307.435 | KNR - KGD | -40000.000 |
| 406 | PVT | 448+766 | 11.12 | 0.77% | PVC | 449+826 | 19.26 | 0.77% | Linear | | 1060.088 | KNR - KGD | |
| 407 | PVC | 449+826 | 19.26 | 0.77% | PVT | 450+065 | 19.51 | -0.56% | Circular | VC203 | 239.534 | KNR - KGD | 18000.000 |
| 408 | PVT | 450+065 | 19.51 | -0.56% | PVC | 452+175 | 7.65 | -0.56% | Linear | | 2110.115 | KNR - KGD | |
| 409 | PVC | 452+175 | 7.65 | -0.56% | PVT | 452+331 | 7.12 | -0.12% | Circular | VC204 | 155.573 | KNR - KGD | -35000.000 |
| 410 | PVT | 452+331 | 7.12 | -0.12% | PVC | 454+114 | 5.02 | -0.12% | Linear | | 1782.480 | KNR - KGD | |
| 411 | PVC | 454+114 | 5.02 | -0.12% | PVT | 454+273 | 4.91 | -0.02% | Circular | VC205 | 159.510 | KNR - KGD | -170000.000 |
| 412 | PVT | 454+273 | 4.91 | -0.02% | PVC | 466+401 | 2.02 | -0.02% | Linear | | 12127.621 | KNR - KGD | |
| 413 | PVC | 466+401 | 2.02 | -0.02% | PVT | 466+507 | 2.1 | 0.17% | Circular | VC206 | 105.952 | KNR - KGD | -55000.000 |
| 414 | PVT | 466+507 | 2.1 | 0.17% | PVC | 469+848 | 7.74 | 0.17% | Linear | | 3341.063 | KNR - KGD | |
| 415 | PVC | 469+848 | 7.74 | 0.17% | PVT | 470+004 | 7.7 | -0.22% | Circular | VC207 | 155.880 | KNR - KGD | 40000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 416 | PVT | 470+004 | 7.7 | -0.22% | PVC | 472+182 | 2.88 | -0.22% | Linear | | 2178.524 | KNR - KGD | |
| 417 | PVC | 472+182 | 2.88 | -0.22% | PVT | 472+314 | 2.81 | 0.11% | Circular | VC208 | 132.343 | KNR - KGD | -40000.000 |
| 418 | PVT | 472+314 | 2.81 | 0.11% | PVC | 474+221 | 4.91 | 0.11% | Linear | | 1906.319 | KNR - KGD | |
| 419 | PVC | 474+221 | 4.91 | 0.11% | PVT | 474+355 | 4.8 | -0.27% | Circular | VC209 | 134.459 | KNR - KGD | 35000.000 |
| 420 | PVT | 474+355 | 4.8 | -0.27% | PVC | 475+699 | 1.11 | -0.27% | Linear | | 1343.588 | KNR - KGD | |
| 421 | PVC | 475+699 | 1.11 | -0.27% | PVT | 475+830 | 0.97 | 0.05% | Circular | VC210 | 131.544 | KNR - KGD | -40000.000 |
| 422 | PVT | 475+830 | 0.97 | 0.05% | PVC | 477+746 | 2.02 | 0.05% | Linear | | 1916.452 | KNR - KGD | |
| 423 | PVC | 477+747 | 2.02 | 0.05% | PVT | 477+857 | 2.18 | 0.24% | Circular | VC211 | 110.413 | KNR - KGD | -60000.000 |
| 424 | PVT | 477+857 | 2.18 | 0.24% | PVC | 479+006 | 4.92 | 0.24% | Linear | | 1149.057 | KNR - KGD | |
| 425 | PVC | 479+006 | 4.92 | 0.24% | PVT | 479+114 | 5.05 | 0.00% | Circular | VC212 | 107.404 | KNR - KGD | 45000.000 |
| 426 | PVT | 479+114 | 5.05 | 0.00% | PVC | 480+014 | 5.05 | 0.00% | Linear | | 900.086 | KNR - KGD | |
| 427 | PVC | 480+014 | 5.05 | 0.00% | PVT | 480+108 | 5.07 | 0.05% | Circular | VC213 | 94.250 | KNR - KGD | -200000.000 |
| 428 | PVT | 480+108 | 5.07 | 0.05% | PVC | 481+854 | 5.89 | 0.05% | Linear | | 1746.216 | KNR - KGD | |
| 429 | PVC | 481+854 | 5.89 | 0.05% | PVT | 481+971 | 5.86 | -0.10% | Circular | VC214 | 116.702 | KNR - KGD | 80000.000 |
| 430 | PVT | 481+971 | 5.86 | -0.10% | PVC | 482+861 | 4.98 | -0.10% | Linear | | 890.109 | KNR - KGD | |
| 431 | PVC | 482+861 | 4.98 | -0.10% | PVT | 482+980 | 4.98 | 0.09% | Circular | VC215 | 119.456 | KNR - KGD | -65000.000 |
| 432 | PVT | 482+980 | 4.98 | 0.09% | PVC | 484+431 | 6.21 | 0.09% | Linear | | 1450.371 | KNR - KGD | |
| 433 | PVC | 484+431 | 6.21 | 0.09% | PVT | 484+533 | 6.26 | 0.02% | Circular | VC216 | 102.346 | KNR - KGD | 150000.000 |
| 434 | PVT | 484+533 | 6.26 | 0.02% | PVC | 486+093 | 6.52 | 0.02% | Linear | | 1560.117 | KNR - KGD | |
| 435 | PVC | 486+093 | 6.52 | 0.02% | PVT | 486+263 | 6.41 | -0.15% | Circular | VC217 | 170.044 | KNR - KGD | 100000.000 |
| 436 | PVT | 486+263 | 6.41 | -0.15% | PVC | 489+182 | 1.93 | -0.15% | Linear | | 2918.366 | KNR - KGD | |
| 437 | PVC | 489+182 | 1.93 | -0.15% | PVT | 489+288 | 2.06 | 0.38% | Circular | VC218 | 106.693 | KNR - KGD | -20000.000 |
| 438 | PVT | 489+288 | 2.06 | 0.38% | PVC | 490+826 | 7.9 | 0.38% | Linear | | 1537.268 | KNR - KGD | |
| 439 | PVC | 490+826 | 7.9 | 0.38% | PVT | 490+950 | 7.94 | -0.31% | Circular | VC219 | 124.539 | KNR - KGD | 18000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 440 | PVT | 490+950 | 7.94 | -0.31% | PVC | 491+948 | 4.83 | -0.31% | Linear | | 997.418 | KNR - KGD | |
| 441 | PVC | 491+848 | 4.83 | -0.31% | PVT | 492+075 | 4.6 | -0.06% | Circular | VC220 | 127.122 | KNR - KGD | -50000.000 |
| 442 | PVT | 492+075 | 4.6 | -0.06% | PVC | 494+118 | 3.43 | -0.06% | Linear | | 2043.339 | KNR - KGD | |
| 443 | PVC | 494+118 | 3.43 | -0.06% | PVT | 494+226 | 3.45 | 0.11% | Circular | VC221 | 108.104 | KNR - KGD | -65000.000 |
| 444 | PVT | 494+226 | 3.45 | 0.11% | PVC | 495+826 | 5.2 | 0.11% | Linear | | 1600.682 | KNR - KGD | |
| 445 | PVC | 495+827 | 5.2 | 0.11% | PVT | 495+951 | 5.59 | 0.52% | Circular | VC222 | 124.494 | KNR - KGD | -30000.000 |
| 446 | PVT | 495+951 | 5.59 | 0.52% | PVC | 497+023 | 11.21 | 0.52% | Linear | | 1071.874 | KNR - KGD | |
| 447 | PVC | 497+023 | 11.21 | 0.52% | PVT | 497+132 | 11.45 | -0.08% | Circular | VC223 | 108.349 | KNR - KGD | 18000.000 |
| 448 | PVT | 497+132 | 11.45 | -0.08% | PVC | 497+798 | 10.93 | -0.08% | Linear | | 666.351 | KNR - KGD | |
| 449 | PVC | 497+798 | 10.93 | -0.08% | PVT | 497+908 | 10.79 | -0.17% | Circular | VC224 | 109.576 | KNR - KGD | 120000.000 |
| 450 | PVT | 497+908 | 10.79 | -0.17% | PVC | 500+766 | 5.95 | -0.17% | Linear | | 2858.568 | KNR - KGD | |
| 451 | PVC | 500+766 | 5.95 | -0.17% | PVT | 500+926 | 5.81 | -0.01% | Circular | VC225 | 160.340 | KNR - KGD | -100000.000 |
| 452 | PVT | 500+926 | 5.81 | -0.01% | PVC | 511+000 | 4.9 | -0.01% | Linear | | 10074.007 | KNR - KGD | |
| 453 | PVC | 511+000 | 4.9 | -0.01% | PVT | 511+121 | 4.83 | -0.11% | Circular | VC226 | 120.272 | KNR - KGD | 120000.000 |
| 454 | PVT | 511+121 | 4.83 | -0.11% | PVC | 512+695 | 3.1 | -0.11% | Linear | | 1574.701 | KNR - KGD | |
| 455 | PVC | 512+695 | 3.1 | -0.11% | PVT | 512+813 | 3.07 | 0.06% | Circular | VC227 | 117.498 | KNR - KGD | -70000.000 |
| 456 | PVT | 512+813 | 3.07 | 0.06% | PVC | 516+861 | 5.45 | 0.06% | Linear | | 4047.893 | KNR - KGD | |
| 457 | PVC | 516+861 | 5.45 | 0.06% | PVT | 516+994 | 5.82 | 0.50% | Circular | VC228 | 133.025 | KNR - KGD | -30000.000 |
| 458 | PVT | 516+994 | 5.82 | 0.50% | PVC | 518+117 | 11.46 | 0.50% | Linear | | 1122.875 | KNR - KGD | |
| 459 | PVC | 518+122 | 11.46 | 0.50% | PVT | 518+233 | 11.79 | 0.07% | Circular | VC229 | 116.201 | KNR - KGD | 27000.000 |
| 460 | PVT | 518+233 | 11.79 | 0.07% | PVC | 519+745 | 12.87 | 0.07% | Linear | | 1511.836 | KNR - KGD | |
| 461 | PVC | 519+745 | 12.87 | 0.07% | PVT | 519+886 | 12.82 | -0.14% | Circular | VC230 | 140.793 | KNR - KGD | 65000.000 |
| 462 | PVT | 519+886 | 12.82 | -0.14% | PVC | 522+901 | 8.45 | -0.14% | Linear | | 3015.072 | KNR - KGD | |
| 463 | PVC | 522+901 | 8.45 | -0.14% | PVT | 523+021 | 8.66 | 0.49% | Circular | VC231 | 120.426 | KNR - KGD | -19000.000 |

| SL No | Point Type | Start Station | Start Elevation | Start Gradient | Point Type | End Station | End Elevation | End Gradient | Element Type | Curve No. | Element Length | Between Stations | Radius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 464 | PVT | 523+021 | 8.66 | 0.49% | PVC | 525+263 | 19.61 | 0.49% | Linear | | 2241.561 | KNR - KGD | |
| 465 | PVC | 525+263 | 19.61 | 0.49% | PVT | 525+579 | 18.38 | -1.27% | Circular | VC232 | 316.000 | KNR - KGD | 18000.000 |
| 466 | PVT | 525+579 | 18.38 | -1.27% | PVC | 526+433 | 7.56 | -1.27% | Linear | | 854.710 | KNR - KGD | |
| 467 | PVC | 526+433 | 7.56 | -1.27% | PVT | 526+695 | 6.15 | 0.19% | Circular | VC233 | 262.006 | KNR - KGD | -18000.000 |
| 468 | PVT | 526+695 | 6.15 | 0.19% | PVC | 528+506 | 9.57 | 0.19% | Linear | | 1811.142 | KNR - KGD | |
| 469 | PVC | 528+506 | 9.57 | 0.19% | PVT | 528+617 | 9.67 | 0.00% | Circular | VC234 | 110.187 | KNR - KGD | 60000.000 |
| 470 | PVT | 528+617 | 9.67 | 0.00% | PVC | 529+900 | 9.74 | 0.00% | Linear | | 1283.399 | KGD - KDD | |
| 471 | PVC | 529+900 | 9.74 | 0.00% | PVT | 530+042 | 9.58 | -0.23% | Circular | VC235 | 141.792 | KGD - KDD | 60000.000 |
| 472 | PVT | 530+420 | 9.58 | -0.23% | POE | 531+296 | 6.68 | -0.23% | Linear | | 1253.923 | KGD - KDD | |

| Sl No | Detail Summary of Vertical Curves | Metre/No | Remarks |
|---|---|---|---|
| 1 | No of Vertical Circular Curved Alignment Between Thiruvananthapuram- Kasaragod | 235 Nos | Vertical Curves |
| 2 | Maximum grade length of the steepest Gradient of 1.56% is 353754-355893 | - | |
| 3 | Maximum Radius of the steepest Gradient of 1.56% is 353754-355893 | - | |

*Abbreviations*

1. *PVC – Point of Vertical Curvature* 2. *PVI – Point of Vertical Intersection*
3. *PVT – Point of Vertical Tangency* 4. *POB – Point of Beginning*
5. *POE – Point of Ending*

## 6.9 SURVEY TECHNOLOGY ADOPTED FOR ALIGNMENT DESCRIPTION

### 6.9.1 Topographical Surveys by Different Methods:-

Due to site inaccessibility issues and time limitations, it was decided to explore modern technology for doing the topographical surveys in minimum possible time with desired quality. The LiDAR survey was found most suitable for the project in the given circumstances based on the reasons as elaborated below;

There are mainly following methods of doing topographical surveys.

- A conventional survey using the Total Station.
- The survey by using Drone Technology
- The survey by using Ariel LiDAR Technology

1. Conventional survey using Total Station: -

Accessibility to the site for surveys before the land acquisition is unlikely in Kerala. The survey by total station requires accessibility to work in the field all along the alignment. Moreover, the progress of the survey by Total station is comparatively slow. Therefore, this conventional method was not found suitable for SilverLine project.

2. Survey by using Drone technology:-

It has limited capability and accuracy for the work. As drone survey is more suitable for the survey of small and clear areas. The SilverLine project is of about 533.350Km so surveying by drone would take longer time. Moreover, the trees and green areas in Kerala also make drone unsuitable for this project.

3. Ariel Survey by using Ariel LiDAR technology

The topographical survey by LiDAR is the latest and modern system of doing topographical surveys. The speed and accuracy can be achieved by LiDAR survey in a better way. The survey can be done in greenfield areas also. Site accessibility is required only for establishing control points, levelling and details collection and verification in the field.

Because of the above reasons, the LiDAR survey was found more suitable in given circumstances and hence adopted for the SilverLine project.

### 6.9.2 Survey Methodology by LiDAR:-

#### 6.9.2.1 Survey Teams:-

A survey team led by the senior team leader conducted a reconnaissance survey along the corridor to study and plan further essential activities. Group of few teams were constituted and deputed to the site for various activities;

#### 6.9.2.2 Project Area

Aerial LiDAR Survey has been carried out over the proposed area of interest for Semi High-Speed corridor from Thiruvananthapuram to Kasaragod of length about 533.470Km. The alignment passes through Kollam, Chengannur, Kottayam, Ernakulam, Thrissur, Kozhikode, Kannur and Kasaragod in Kerala. Index plan of alignment along with details is placed at Figure 6.25.


**Figure 6-25: Index Plan showing the SilverLine Corridor**

#### 6.9.2.3 The sequential activities to complete the Topographical survey

1. Collection of Survey of India reference GTS benchmark and verification at site
2. Establishment of control points
3. Approval of DGCA of LiDAR aircraft to fly for capturing the data Necessary clearances from Director General of Civil Aviation, Ministry of Defense, Government of India, and other agencies are required to complete the job of flying and capturing the data.
4. Flight Planning including preparation of flying paths
5. Ariel LiDAR survey by data capturing in 600m width along the corridor
6. Data processing to develop the CAD plans and other reports and DTM data
7. Site verification and collection of other filed data.

#### 6.9.2.4 Collection of GTS bench marks from Survey of India

Following GTS bench marks were obtained from Survey of India, Thiruvananthapuram for using as reference points for LiDAR survey and verified at site, and 10 out of the total 22 points were available for use as per details given below;

**Table 6-51: List of SOI's GTS bench marks**

| Sl. No. | GTS No. | Latitude | Longitude | Description | Available | Useful/ Not Useful | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 134 | 8'3015" N | 7556'55' E | Thiruvanathapuram | | | |
| 2 | 155 | 8'4522" N | 755151' E | Vamanapuram | Yes | Useful | |
| 3 | 225 | 9'14'33" N | 754(120" E | Kulanada | Yes | Useful | |
| 4 | 257 | 9'26'35' N | 76'3220' E | Cheganacheny | Yes | Useful | |
| 5 | 276 | 9'34'54" N | 76'31'21" E | Kottayam | Yes | Useful | |
| 6 | 349 | 9.58.35' N | 76'16'41 E | Ernakulam | Yes | Useful | |
| 7 | 365 | 10'06'08" N | 76'21'30r E | Aluva | Yes | Useful | |
| 8 | 393 | | | Chalakkudy | No | Not Useful | Removed |
| 9 | 472 | 10'4509" N | 76'07'40" | Trithala | Yes | Usful | |
| 10 | 494 | | | Kuttipuram | No | Not Useful | Removed |
| 11 | 514 | | | Tirur | No | Not Useful | Covered in Road by Concrete Blocks |
| 12 | 540 | | | Parappanagadi | No | Not Useful | Removed |
| 13 | 563 | | | Baypore | | Not Useful | Not Available |
| 14 | 574 | 11'1531" N | 7546'11" | Kozhikode | Yes | Useful | |
| 15 | 596 | | | Quilandy | No | Not Useful | Not Available |
| 16 | 617 | | | Vadakara | No | Not Useful | Not Available |
| 17 | 635 | | | Thalassery | No | Not Useful | Removed |
| 18 | 680 | 12'02'10" N | 7521'44' | Taliparamba | Yes | Useful | |
| 19 | 699 | | | Payyanur | No | Not Useful | Not Available |
| 20 | 718 | 12'14'50" N | 7508'02" | Nileshwar | Yes | Not Useful | Not Useful due to inside of building and sky is not visible |
| 21 | 727 | 12'18'44" N | 7505'20" | Kanhangad | Yes | Useful | |
| 22 | 760 | 12'79'59" N | 7459'11" | Kasaragod | Yes | Not Useful | Not Useful due to inside of building and sky is not visible |

#### 6.9.2.5 Establishment of Control Points :-

For establishment of control points in the field to facilitate the LiDAR survey, there was a need for establishing 3 types of control points as per description given below;

1. MCP (Master Control Points) at every 25 km in a triangle for making network for map projection purpose.
2. SCP (Secondary Control Points) pillars every 25 km along the alignment.
3. TCP (Target Control Points for Ariel LiDAR survey flying time use) at every 25 KM interval along alignment.
4. TCP (Additional Control Points) every 5 km along the alignment

#### 6.9.2.6 Discussion on MCP, SCP and TCPs established at site :-

Survey teams of experts in desired numbers with DGPS and other equipments were deployed to the site in the entire corridor to establish the MCP, SCP, TCP and TCP (additional) as per details show below.

**Table 6-52: Details of MCP, SCP and TCPs**

| S.No. | Type of control points | Interval | Total no's of control points | Remarks |
|---|---|---|---|---|
| 1 | MCP | 25 KM | 43 | Paint Marking on BT road |
| 2 | SCP | 5KM | 22 | Fixed with pillars |
| 3 | TCP | 25 KM | 22 | TCP is marked with white circular paint and nail point on the top of the corner of the BT road. |
| 4 | TCP<br>(Additional Points) | 5 KM | 72 | Along the Alignment on permanent structures on road edge with paint marking |

#### 6.9.2.7 Typical Details of MCP, SCP And TCPS fixed at site :-

All these control points were fixed at site. Site pictures and details of locations are given for all the points in Survey Report of the SilverLine Project in Volume 4 Part 1. In this DPR, only the typical figures and the details are given to indicate how and where the MCP, SCP and TCPs are fixed at site with details of co-ordinates, MSL level and description of location so that these can be identified later as given in paragraphs here under;

| GEOGRAPHIC COORDINATES (DEG MIN SEC) | | | UTM COORDINATES (METERS) | | |
|---|---|---|---|---|---|
| LATITUDE | LONGITUDE | MSL | EASTING | NORTHING | MSL |
| 8° 27' 23.87848" N | 76° 56' 09.62072" E | | 713141.204 | 935309.608 | |
| DESCRIPTION | The survey station, K-RAIL-01-MCP is marked with red and white paint and nail point on the top of BSF lane BT road. The survey station is near by Bemapally mosque. It is approximately 2 metres away from the flag Pole. | | | | |
| **LOCATION ON GOOGLE MAP** | | | **FIELD PHOTOGRAPH** | | |
|  | | |  | | |

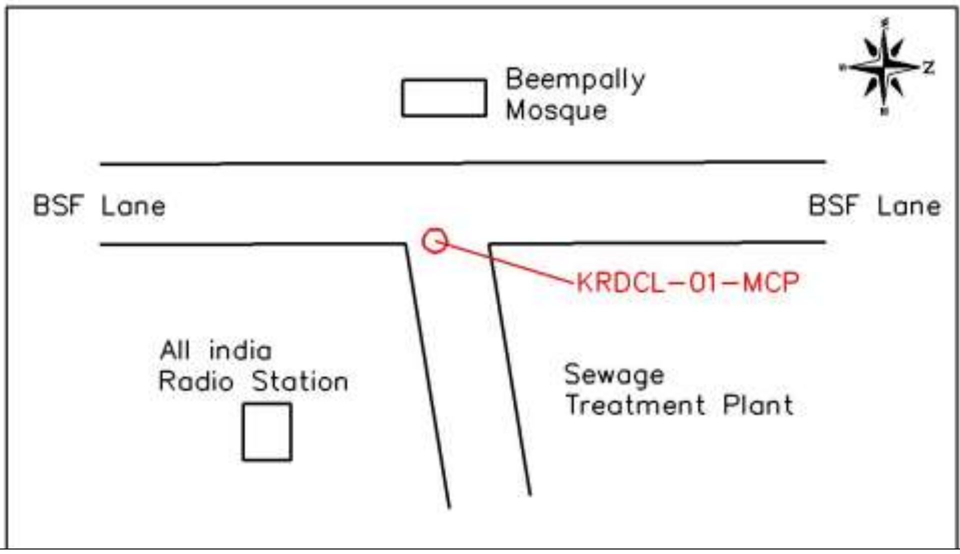



**Figure 6-23: Typical Figure showing MCP location**

| GEOGRAPHIC COORDINATES (DEG MIN SEC) | | | UTM COORDINATES (METERS) | | |
|---|---|---|---|---|---|
| LATITUDE | LONGITUDE | MSL | EASTING | NORTHING | MSL |
| 8° 28' 53.77693" N | 76° 55' 46.68898" E | | 712425.956 | 938068.370 | |
| DESCRIPTION | The survey station, K-RAIL-001-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Karali road. The survey station is near by shibu agencies,korali. It is approximately 2 metres away from the Parvathi Puthan river. | | | | |

| LOCATION ON GOOGLE MAP | FIELD PHOTOGRAPH |
|---|---|
|  |  |

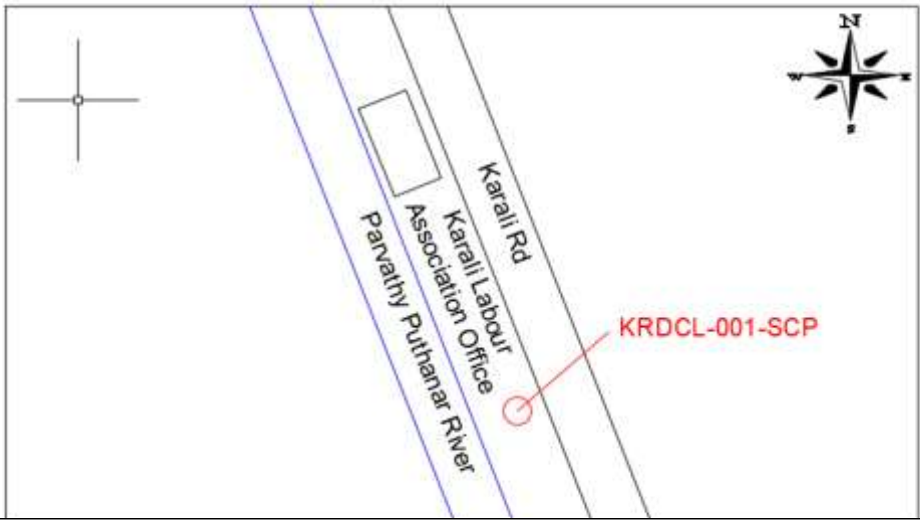



**Figure 6-24: Typical Figure showing SCP location**

| GEOGRAPHIC COORDINATES ( DEG MIN SEC) | | | UTM COORDINATES (METERS) | | |
|---|---|---|---|---|---|
| LATITUDE | LONGITUDE | MSL | EASTING | NORTHING | MSL |
| 8° 32' 33.19709" N | 76° 52' 29.56120" E | | 706363.127 | 944780.598 | |
| DESCRIPTION | The survey station, K-RAIL-003-TCP/TCP is marked with white circular paint and nail point on the top of the corner of the BT road. The survey station is near by residential building,thumba. It is approximately 5 metres away from the Railway track. | | | | |
| **LOCATION ON GOOGLE MAP** | | | **FIELD PHOTOGRAPH** | | |
|  | | |  | | |

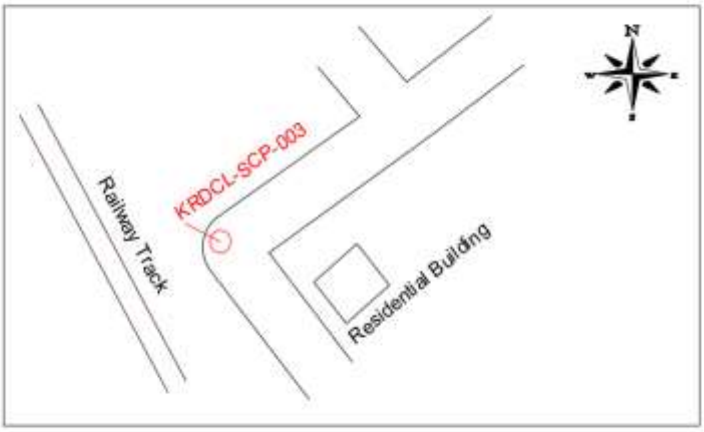



**Figure 6-25: Typical Figure showing TCP location**

| **GEOGRAPHIC COORDINATES ( DEG MIN SEC)** | | | **UTM COORDINATES (METERS)** | | |
|---|---|---|---|---|---|
| LATITUDE | LONGITUDE | MSL | EASTING | NORTHING | MSL |
| 8° 30' 29.51542" N | 76° 54' 08.53035" E | | 709408.815 | 940995.198 | |
| DESCRIPTION | The survey station, K-RAIL-002-SCP is marked with red and white paint and nail point on the top of the Parvathi<br>Puthan River BT road. The survey station is near by parvathi puthan river. It is approximately 10 metres away from the electric pole. | | | | |
| **LOCATION ON GOOGLE MAP** | | | **FIELD PHOTOGRAPH** | | |
|  | | |  | | |



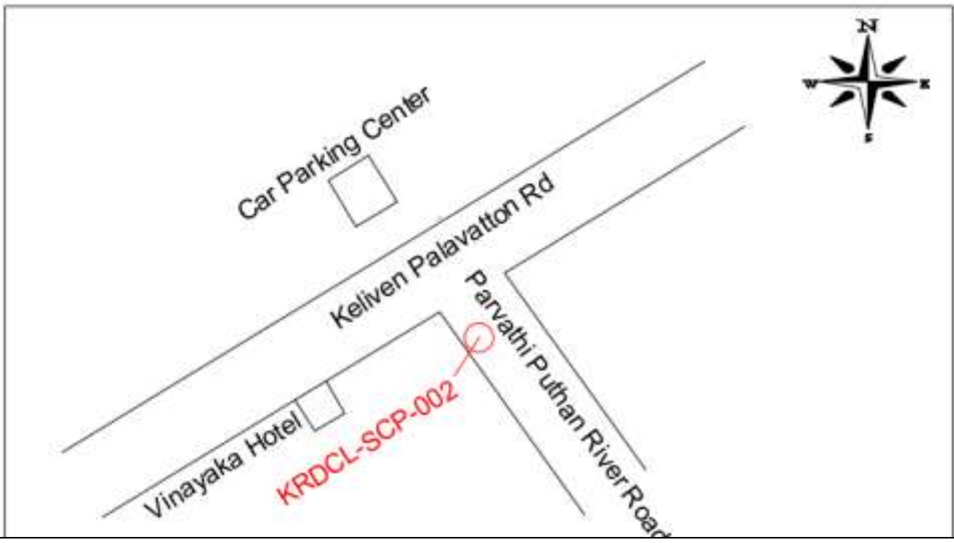




**Figure 6-26: Typical Figure showing TCP location**

### 6.9.3 LIST OF MAIN CONTROL POINTS

The details of all control points covering MCP, SCP and TCPs with Easting, Northing and Z value wide description are given below ;

**Table 6-53: List of MCP fixed at every 25 Km on ground**

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 1 | MCP 1 | 713141.204 | 935309.608 | 4.811 | The survey station, 01-MCP is marked with red and white paint and nail point on the top of BSF lane BT road. The survey station is nearby Bemapally mosque. It is approximately 2 meters away from the flag Pole. |
| 2 | MCP 2 | 711297.215 | 951549.991 | 103.465 | The survey station,02-MCP is marked with red and white paint and nail point on the top of Maruthumoodu-Aruvikarakonam BT road. The survey station is nearby Residential House no: SP8/176(20). It is approximately 8 meters away from the road junction. |
| 3 | MCP 3 | 695515.749 | 956202.028 | 3.653 | The survey station, 03-MCP is marked with red and white paint and nail point on the top of Chillaroor-Vallakada BT road. The survey station is parallel Mutalapozhi river in Thazhampalli. It is approximately 14 meters away from the electric pole. |
| 4 | MCP 4 | 704390.419 | 970570.343 | 23.321 | The survey station, 04-MCP is marked with red and white paint and nail point on the top of concrete slab covering a drain on the side of the Malayodam-Pappala BT road. The survey station is nearby drain to the side of Malayamadom-Pappla Road. It is approximately 22 meters away from the telephone pole. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 5 | MCP 5 | 684207.962 | 974553.22 | 4.376 | The survey station, 05-MCP is marked with red and white paint and nail point on the top of road. The survey station is nearby railway cross on the Parapally-Paravur road. It is approximately 13 meters away from the Mahadev automobile. |
| 6 | MCP 6 | 692134.854 | 986823.756 | 37.347 | The survey station, 06-MCP is marked with red and white paint and nail point on the top of Ambalakunnu-Kundara BT Road. The survey station is nearby Nedumankavu - Veliyam Road. It is approximately 6 meters away from the electric pole. |
| 7 | MCP 7 | 677243.985 | 999628.814 | 20.987 | The survey station, 07-MCP is marked with red and white paint and nail point on the top of Railway staion BT road that leads to the ICS junction railway station. The survey station is nearby Chavara - Sasthamkotta Road. It is approximately 1 meters away from the flag Pole. |
| 8 | MCP 8 | 689116.882 | 1013165.762 | 45.903 | The survey station, 08-MCP is marked with red and white paint and nail point on the top of culvert to the side of the Adoor-Charrumoodu BT road. The survey station is nearby Adoor Federal bank. It is approximately 1.5 meters away from the flag Pole. |
| 9 | MCP 9 | 674353.732 | 1024965.979 | 5.907 | The survey station, 09-MCP is marked with red and white paint and nail point on the top of Mavellikara-Chengannur-Kozhelchery BT Road. The survey station is nearby bridge on SH10 in Cheriyanad. It is approximately 31 meters away from the Ponni Stores. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 10 | MCP 10 | 685213.252 | 1039009.253 | 36.727 | The survey station, 10-MCP is marked with red and white paint and nail point on the top of BT road. The survey station is nearby residential bulding on the side of Podippara - Nellimala Road. It is approximately 200 meters away from the Government Hospital. |
| 11 | MCP 11 | 669601.127 | 1042684.875 | 5.024 | The survey station, 11-MCP is marked with red and white paint and nail point on the top of Kollam-Theni highway BT road. The survey station is nearby Perunna bus stop. It is approximately 13 meters away from the solar powered Lamp post. |
| 12 | MCP 12 | 677978.904 | 1058739.819 | 20.266 | The survey station, 12-MCP is marked with red and white paint and nail point on the top of culvert on the side of Kottayam-Pambady BT road. The survey station is nearby Residential House no: 60 in Pampady village. It is approximately 1 meter away from the wooden telephone pole. |
| 13 | MCP 13 | 661877.078 | 1071832.473 | 3.096 | The survey station, 13-MCP is marked with red and white paint and nail point on the top of the old bridge on top of Kallara river Parallel to Kumarakonam-Cumbom BT road. The survey station is nearby Kallara river bridge in Perumthuruth. It is approximately 18 meters away from the electric pole. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 14 | MCP 14 | 670868.251 | 1086808.59 | 17.655 | The survey station, 14-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Thalayolaparambu-Koothattukulam BT road. The survey station is nearby Residential building in Muttathupuram. It is approximately 2 meters away from the telephone pole. |
| 15 | MCP 15 | 651002.129 | 1092223.695 | 4.964 | The survey station, 15-MCP is marked with red and white paint and nail point to the side of the junction between the Ettmanoor-Ernakulam BT Road and Udayamperoor BT Road. The survey station is nearby Udayamperamboor colony Bus Stop. It is approximately 8 meters away from the Sachu stores. |
| 16 | MCP 16 | 659632.646 | 1108386.98 | 28.604 | The survey station, 16-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Ernakuolam-Thekkady BT road. The survey station is nearby Chengara-Chirangara mosque. It is approximately 15 meters away from the power tools shop. |
| 17 | MCP 17 | 646237.838 | 1114750.149 | 9.217 | The survey station, 17-MCP is marked with red and white paint and nail point on the top of Bridge of the Idamoola BT road on top of the Muttar river. The survey station is nearby Edamula Masjid. It is approximately 1 meters away from the lamp post. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 18 | MCP 18 | 651655.268 | 1133151.913 | 26.191 | The survey station, 18-MCP is marked with red and white paint and nail point on the top of culvert to the side of a village BT road. The survey station is nearby Vargesh market in Karukutty vilage. It is approximately 25 meters away from the transformer. |
| 19 | MCP 19 | 632261.534 | 1135747.719 | 8.980 | The survey station, 19-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Kodunallur-Shornur BT road. The survey station is nearby Karupadanna Masjid. It is approximately 1 meters away from the name board. |
| 20 | MCP 20 | 639953.733 | 1151374.367 | 8.386 | The survey station,20-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Shantinagar-Kuttumuck-Kuttiyal BT road. The survey station is nearby Pudukad bus stop. It is approximately 5 meters away from the residential building. |
| 21 | MCP 21 | 627518.7 | 1160716.003 | 5.044 | The survey station, 21-MCP is marked with red and white paint and nail point on the top of road junction formed between Vadanapally-Kanjany-Thrissur BT road and Manakkodi Pullu BT road. The survey station is nearby Manakadi Bus stop. It is approximately 3 meters away from the telephone pole. |
| 22 | MCP 22 | 631755.971 | 1175687.422 | 14.418 | The survey station, 22-MCP is marked with red and white paint and nail point on the top of concrete slab across the Puzhakkal river parallel to the Athani-Thiruthiparambu BT road. The survey station is nearby Thiruthu-Paramba Road in Atanai Village. It is approximately 21 meters away from the pump Shed. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 23 | MCP 23 | 609460.213 | 1176096.639 | 3.236 | The survey station, 23-MCP is marked with red and white paint and nail point on the top of culvert on top of a nala and on the side of the Punnayoor BT road. The survey station is nearby Puriyanoor panchayat office. It is approximately 46 meters away from the Post office. |
| 24 | MCP 24 | 618841.057 | 1192870.915 | 15.139 | The survey station, 24-MCP is marked with red and white paint and nail point on the top of culvert. The survey station is nearby Farm house in Pattitara. It is approximately 50 meters away from the Ponmani-Palakad BT road. |
| 25 | MCP 25 | 598776.177 | 1197396.741 | 4.327 | The survey station, 25-MCP is marked with red and white paint and nail point on the top of retaining structure. The survey station is nearby Kattedaipalli Masjid. It is approximately 100 meters away from the Purathur Service Sahakarna Bank. |
| 26 | MCP 26 | 606557.328 | 1214768.179 | 8.949 | The survey station, 26-MCP is marked with red and white paint and nail point on the top of a Village BT road. The survey station is near by Turkish Global Furniture in Permanna Village. It is approximately 50 meters away from the Thrissur-Malappuram BT road. |
| 27 | MCP 27 | 593267.785 | 1219981.997 | 3.362 | The survey station, 27-MCP is marked with red and white paint and nail point on the top of bridge over the Tippusulthan BT road. The survey station is nearby Badriyya Jumma Masjid. It is approximately 100 meters away from the Aviyal Valiya Jumma Masjid. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 28 | MCP 28 | 594428.769 | 1238751.705 | 10.337 | The survey station, 28-MCP is marked with red and white paint and nail point on the top of bridge of the Kottakal-Alapuzha BT road. The bridge stands across the Chaliyar River. It is approximately 70 meters away from the Standard Cars. |
| 29 | MCP 29 | 583732.147 | 1245182.605 | 3.109 | The survey station, 29-MCP is marked with red and white paint and nail point on the top of retaining structure on the side of the mud road leading towards the beach from the Beach BT road. The survey station is nearby KSES Employees society in Kozhikode. It is approximately 50 meters away from the building under construction. |
| 30 | MCP 30 | 586262.096 | 1265545.989 | 57.727 | The survey station, 30-MCP is marked with red and white paint and nail point near a culvert on the top of the Koyilandy-Thamaraserry BT road. The survey station is nearby Parambinate bus stop. It is approximately 15 meters away from the IRC bakery. |
| 31 | MCP 31 | 569877.471 | 1268403.309 | 11.386 | The survey station, 31-MCP is marked with red and white paint and nail point on the top of H.W bridge over the NH66 BT Road. The survey station is nearby Chinagapuram bus stop. It is approximately 16 meters away from the Freekzz beauty parlour. |
| 32 | MCP 32 | 574304.244 | 1284805.041 | 4.117 | The survey station, 32-MCP is marked with red and white paint and nail point on the top of culvert to the side of the Ayancherry-Thiruvallur BT road. The survey station is nearby General store in Ayanchery Village. It is approximately 8 meters away from the temple. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 33 | MCP 33 | 558214.746 | 1293135.987 | 4.680 | The survey station, 33-MCP is marked with red and white paint and nail point on the top of culvert to the side of the Mahe Beach BT road. The survey station is nearby NH66 on Parakkal Village. It is approximately 30 meters away from the Police station. |
| 34 | MCP 34 | 559151.972 | 1307949.151 | 37.297 | The survey station, 34-MCP is marked with red and white paint and nail point on the top of base of the well. The well is on the side of the Chovva-Kuthuparamba BT Road. It is approximately 10 meters away from the residential building. |
| 35 | MCP 35 | 538386.341 | 1312359.78 | 7.390 | The survey station, 35-MCP is marked with red and white paint and nail point on the top of bridge of the Bayamballam beach BT road. The survey station is nearby Payambalam Crematorium. It is approximately 40 meters away from the footpath. |
| 36 | MCP 36 | 540832.897 | 1325343.178 | 31.942 | The survey station, 36-MCP is marked with red and white paint and nail point on the top of culvert near the junction of the EMS BT road on the Tali Paramba-Kannur BT Road. The survey station is nearby Coffee day Shop in Aroli Village. It is approximately 50 meters away from the petrol station. |
| 37 | MCP 37 | 523275.266 | 1327731.269 | 5.577 | The survey station, 37-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Ettikukulam beach BT road. The survey station is nearby near a shop on the Ettikulam beach. It is approximately 120 meters away from the sea shore. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 38 | MCP 38 | 529268.741 | 1342652.355 | 38.667 | The survey station, 38-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Mathil-Perul-Mathamangalam BT road. The survey station is nearby Pullupura Bus stop. It is approximately 20 meters away from the residential building. |
| 39 | MCP 39 | 512799.361 | 1350069.485 | 2.521 | The survey station, 39-MCP is marked with red and white paint and nail point on the top of a concrete slab covering a drainage on the side of the Azhithala BT road. The survey station is nearby Alinkal Sree Batrakali Temple. It is approximately 40 meters away from the commercial building. |
| 40 | MCP 40 | 514266.661 | 1367124.27 | 79.086 | The survey station, 40-MCP is marked with red and white paint and nail point on the top of culvert on the side of the Kanhangad-Rajapuram-Malom BT road. The survey station is nearby Residential building in Ambalathara. It is approximately 30 meters away from the road junction. |
| 41 | MCP 41 | 502431.894 | 1372038.852 | 4.950 | The survey station, 41-MCP is marked with red and white paint and nail point on the top of concrete slab covering a drinage on the side of the Kochi-Panvel Highway BT road. The survey station is nearby Thikkannad Tyanbakeshwara Temple. It is approximately 10 meters away from the petty shop. |
| 42 | MCP 42 | 504058.432 | 1387741.047 | 84.340 | The survey station,42-MCP is marked with red and white paint and nail point on the top of culvert on the side of Vidya Nagar BT road. The survey station is nearby petty shop in Kollangana Village. It is approximately 100 meters away from the mosque. |

| Sl. No. | MCP No | EASTING | NOTRHING | Z (MSL) | Description |
|---|---|---|---|---|---|
| 43 | MCP 43 | 497015.602 | 1382455.35 | 5.275 | The survey station, 43-MCP is marked with red and white paint and nail point on the top of foot path of a local park near the Kasargod Beach. The survey station is nearby Kasargod Light house. It is approximately 20 meters away from the transformer. |

**Table 6-54: List of TCPs fixed at 25 Km along the alignment on ground**

| Sl No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 1 | 003-TCP | 706363.1 | 944780.6 | 6.023 | The survey station,003 TCP is marked with white circular paint and nail point on the top of the corner of the BT road. The survey station is nearby residential building, thumba. It is approximately 5 meters away from the railway track. |
| 2 | 007-TCP | 698301.7 | 964253.2 | 36.087 | The survey station,007 TCP is marked with white circular paint and nail point on the top of the Alamcode-kadakkavoor-Anchutengu BT road. The survey station is near by bus stop, Kadakkvoor. It is approximately 2 meters away from the electric pole. |
| 3 | 013-TCP | 682028.4 | 984049.1 | 4.536 | The survey station,013 TCP is marked with white circular paint and nail point on the top of the concrete slab on the side of the Kollam bypass river. The survey station is nearby kollam nalla, mukhathala. It is approximately 20 meters away from the residential building. |
| 4 | 018-TCP | 683930.1 | 1005707 | 14.605 | The survey station,018 TCP is marked with white circular paint and nail point on the top of the Chakkuvally-Kadambanad BT road. The survey station is nearby Edakkadu. It is approximately 100 meters away from the church. |
| 5 | 022 TCP | 680544.5 | 1031568 | 8.137 | The survey station,022 TCP is marked with white circular paint and nail point on the top of the Movelikkona-Kozhenchery BT road. The survey station is nearby Gek enterprises, Arattupuzha. It is approximately 2 meters away from the name board. |

| Sl No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 6 | 023_A-TCP | 679980.1 | 1032772 | 10.766 | The survey station,023_A-SCP/TCP is marked with white circular paint and nail point on the top of the road corner BT road. The survey station is nearby agriculture land, Chengannur village. It is approximately 10 meters away from the residential building. |
| 7 | 028-TCP | 671490.9 | 1053232 | 3.261 | The survey station,028 TCP is marked with white circular paint and nail point on the top of the culvert. The culvert is on the Pallom-Njaliakhuzhi BT road. The survey station is nearby pathiyapallykkadavu bridge. It is approximately 20 meters away from the tea shop. |
| 8 | 032-TCP | 672390.2 | 1069421 | 11.888 | The survey station,032 TCP is marked with white circular paint and nail point on the top of the Ettumanoor-pala-poonjan BT road. The survey station is near by bus stop. It is approximately 30 meters away from the sign board. |
| 9 | 037-TCP | 662973.9 | 1088236 | 5.667 | The survey station,037-TCP is marked with white circular paint and nail point on the top of the Vellore-Moolakulam BT road. The survey station is nearby residential building,mulakulam. It is approximately 10 meters away from the electric pole. |
| 10 | 043-TCP | 653317.4 | 1115576 | 26.772 | The survey station,043-SCP/TCP is marked with white circular paint and nail point on the top of the Aluva-Munnar BT road. The survey station is nearby kundali road crossing,vazhakulam village. It is approximately 10 meters away from the zain hotel. |
| 11 | 048-TCP | 642872.5 | 1132941 | 7.759 | The survey station, 048 - TCP is marked with white circular paint and nail point on the top of the Alathur-vannoor BT road. The survey station is nearby saint mary's church, vannoor village. It is approximately 5 meters away from the church program hall. |

| Sl No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 12 | 053-TCP | 631218.5 | 1153167 | 6.630 | The survey station, 053-TCP is marked with white circular paint and nail point on the top of the Cherpu- Thriprayar BT road. The survey station is nearby co-operative bank,cherpu village. It is approximately 30 meters away from the padinattamuri bus stop. |
| 13 | 058-TCP | 623202.8 | 1174451 | 26.616 | The survey station,058-TCP is marked with white circular paint and nail point on the top of the wadakkancherry-kurancherry-velor BT road. The survey station is nearby vazhanai canal. It is approximately 40 meters away from the najith stores. |
| 14 | 062-TCP | 611174.7 | 1192389 | 9.426 | The survey station,062-TCP is marked with white circular paint and nail point on the top of the Palakkad-Ponnai BT road. The survey station is nearby seena biryani center. It is approximately 5 meters away from the women city ladies club. |
| 15 | 068-TCP | 595219.6 | 1217538 | 9.056 | The survey station,068-TCP is marked with white circular paint and nail point on the top of the concrete slab covering a drainage on the side of the Thirur-Kadalundi BT road. The survey station is nearby konangotu sree bhadrakali temple. It is approximately 5 meters away from the garments shop. |
| 16 | 074-TCP | 584856.1 | 1244449 | 14.706 | The survey station,074-TCP is marked with white circular paint and nail point on the top of the CH flyover, an over the railway bridge of the Red cross road. The survey station is nearby TM steels and cement shop. It is approximately 2 meters away from the electric pole. |
| 17 | 078-TCP | 577251.8 | 1263044 | 17.049 | The survey station,078-TCP is marked with white circular paint and nail point on the top of the over the railway bridge of the Panvel-Kochi-Kanniyakumari highway near Koyilandy town. The survey station is near by retaining wall. It is approximately 5 meters away from the street lamp. |

| Sl No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 18 | 083-TCP | 566295.5 | 1283338 | 5.684 | The survey station,083-TCP is marked with white circular paint and nail point on the top of the Nadakuthazha-Alangulakara BT road. The survey station is nearby cultivation land. It is approximately 10 meters away from the EHT pole. |
| 19 | 088-TCP | 555759.1 | 1305572 | 10.916 | The survey station,088-TCP is marked with white circular paint and nail point on the top of the Panthakkapara-Kappumal BT road. The survey station is nearby residential building,pinarayi vilaage. It is approximately 15 meters away from the chalil sree muthappan madawpam temple. |
| 20 | 095-TCP | 531666.4 | 1326418 | 2.279 | The survey station,095-TCP is marked with white circular paint and nail point on the top of the Pilathara-Pappinisseri BT road. The survey station is nearby vellarangal post office. It is approximately 15 meters away from the railway track. |
| 21 | 101-TCP | 516996.4 | 1349907 | 4.381 | The survey station,101-TCP is marked with white circular paint and nail point on the top of the service BT road under the Cheruvathur-Panvel over the railway bridge. The survey station is nearby over bridge,cheruvathur-achanthurath. It is approximately 10 meters away from the railway track. |
| 22 | 106-TCP | 503595.8 | 1370836 | 17.717 | The survey station,106-SCP/TCP is marked with white circular paint and nail point on the top of the over the railway bridge of Bekal--Periyathadukkam Road, near Bekal Town. The survey station is nearby illyas juma masjid,kheleniya village. It is approximately 30 meters away from the adhi katrumula malingamasthery temple. |

**Table 6-55: List of SCPs fixed at 25km along alignment on pillars**

| Sl. No. | DGPS/K-RAIL POINT ID SCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 1 | 001-SCP | 712425.956 | 938068.37 | 3.369 | The survey station,001-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Karali road. The survey station is nearby shibu agencies,korali. It is approximately 2 meters away from the Parvathi Puthan river. |
| 2 | 005-SCP | 701070.033 | 953163.024 | 7.007 | The survey station,005-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Chiriyankeezhu-Kanniyapuram road. The survey station is nearby junction, nellmood koyhinada road. It is approximately 70 meters away from the railway track. |
| 3 | 010-SCP | 695617.209 | 976427.145 | 43.584 | The survey station,010-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Paripally-Valamanoor Road. The survey station is nearby residential building,valamanoor. It is approximately 70 meters away from the government school. |
| 4 | 015-SCP | 685245.959 | 992326.302 | 37.757 | The survey station,015-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Kanadara-Chittumala Road. The survey station is nearby kannimel bus stop. It is approximately 10 meters away from the electric pole. |

| Sl. No. | DGPS/K-RAIL POINT ID SCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 5 | 020-SCP | 680248.236 | 1016615.94 | 18.917 | The survey station,020-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Kundasandd-Bharahickauu Road. The survey station is nearby residential building,kidangayam. It is approximately 5 meters away from the icds office. |
| 6 | 025-SCP | 678941.137 | 1047428.78 | 32.072 | The survey station, 025-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Mammood-Mallapally Road. The survey station is nearby residential building,santhipuram. It is approximately 30 meters away from the electric pole. |
| 7 | 030-SCP | 668636.019 | 1060322.22 | 27.423 | The survey station,030-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Kottayam-Kumily Road. The survey station is nearby chrysoberyl hotel,kanjikuzhy. It is approximately 200 meters away from the railway track. |
| 8 | 035-SCP | 666213.819 | 1081895.75 | 11.205 | The survey station,035-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Nieezhoor-Kaduthuruthy road. The survey station is nearby residential building,njeezhoor. It is approximately 20 meters away from the electric pole. |

| Sl. No. | DGPS/K-RAIL POINT ID SCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 9 | 040-SCP | 650910.912 | 1099911.01 | 4.449 | The survey station,040-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Kochi-Madurai road. The survey station is nearby hotel joyce,mamala. It is approximately 20 meters away from the river. |
| 10 | 046-SCP | 651046.747 | 1125569.29 | 25.180 | The survey station,046-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Salem-Kochi road. The survey station is near by fire and rescue station. It is approximately 2 meters away from the ofc stone. |
| 11 | 050-SCP | 640941.917 | 1139662.66 | 22.313 | The survey station,050-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Chalakudy-Komodinamakkal road. The survey station is nearby residential building,chalakudy village. It is approximately 2 meters away from the canal. |
| 12 | 055-SCP | 632167.112 | 1163678.34 | 12.749 | The survey station,055-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Dilkush road. The survey station is nearby railway overbridge . It is approximately 15 meters away from the vijayasree eye hospital. |

| Sl. No. | DGPS/K-RAIL POINT ID SCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 13 | 060-SCP | 615795.538 | 1182855.34 | 10.505 | The survey station,060-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Pazhanji-Kadavallor road. The survey station is nearby cheenikkal ayyappa temple,aynoor village. It is approximately 8 meters away from the electric pole. |
| 14 | 065-SCP | 600931.737 | 1206743.38 | 9.130 | The survey station,065-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Tirur-Malapuram road.. The survey station is nearby new light electrical and CV metals. It is approximately 15 meters away from the railway track. |
| 15 | 071-SCP | 590304.193 | 1231264.84 | 3.266 | The survey station,071-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Kadalundy road.. The survey station is nearby railway crossing. It is approximately 15 meters away from the tea shop. |
| 16 | 076-SCP | 580859.307 | 1254189.85 | 4.437 | The survey station,076-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of local village road parallel to the railway track near the Elatthur railway station. The survey station is nearby railway crossing. It is approximately 1 meters away from the electric pole. |

| Sl. No. | DGPS/K-RAIL POINT ID SCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 17 | 080-SCP | 570115.675 | 1271018.98 | 2.098 | The survey station,080-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Purakkad-Muchukunnu Road. The survey station is nearby residential building. It is approximately 3 meters away from the street lamp. |
| 18 | 085-SCP | 560439.073 | 1290970.71 | 7.726 | The survey station,085-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Orkatheri-Kunjipally Road. The survey station is nearby signboard. It is approximately 10 meters away from the electric pole. |
| 19 | 092-SCP | 539711.744 | 1312829.47 | 9.498 | The survey station,092-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. . The survey station is nearby on the side of the mud road infront of sreedaran company private limited. It is approximately 5 meters away from the railway track. |
| 20 | 098-SCP | 521033.705 | 1337286.97 | 3.801 | The survey station,098-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Ezhimala-Payyanoor road. The survey station is nearby kotty railway station. It is approximately 15 meters away from the axis bank. |
| 21 | 104-SCP | 509067.7 | 1362334.18 | 6.689 | The survey station,104-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of BT road that leads to the Kanhagad railway station. The survey station is nearby kanhangad railway station. It is approximately 15 meters |

| Sl. No. | DGPS/K-RAIL POINT ID SCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| | | | | | away from the railway gate office building. |
| 22 | 108-SCP | 499550.91 | 1379244.5 | 2.379 | The survey station,108-SCP is marked with a plus sign engraved on a metal plate on the top of the pillar. The pillar is erected on the side of Kasargod beach road. The survey station is nearby kasargod road. It is approximately 8 meters away from the railway track. |

**Table 6-56: List of Additional TCPs at every 5Km along alignment**

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 1 | 002-TCP | 709408.8 | 940995.2 | 3.535 | The survey station,002-SCP is marked with red and white paint and nail point on the top of the Parvathi Puthan River BT road. The survey station is nearby parvathi puthan river. It is approximately 10 meters away from the electric pole. |
| 2 | 004-TCP | 704032.7 | 949805.8 | 10.125 | The survey station, 004-SCP is marked with red and white paint and nail point on the top of the Kanniyapuram railway staion BT road. The survey station is nearby raiway station,kaniyapuram. It is approximately 5 meters away from the railway track. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 3 | 006-TCP | 698524.1 | 958032.3 | 12.414 | The survey station,006-SCP is marked with red and white paint and nail point on the top of the Kizhuvilam Service Co-Operative bank road BT road. The survey station is nearby kattumarakkal jumma masjid. It is approximately 70 meters away from the bhahmapuri temple. |
| 4 | 008-TCP | 698757.2 | 969675 | **53.540** | The survey station,008-SCP is marked with red and white paint and nail point on the top of the Kallabalam-Puthusarimukku-Killimanoor BT road. The survey station is nearby tailor shop,puthuserinkku. It is approximately 20 meters away from the electric pole. |
| 5 | 009-TCP | 697968.7 | 972568 | 93.020 | The survey station,009-SCP is marked with red and white paint and nail point on the top of the culvert on the side of the Navikkal-Pallikal BT road. The survey station is nearby csi church,maruthi kunnu. It is approximately 2 meters away from the electric pole. |
| 6 | 011-TCP | 690724.6 | 978350.3 | 52.211 | The survey station,011-SCP is marked with red and white paint and nail point on the top of the Panavel-Kochi-Kanniyakumari Highway BT road. The survey station is nearby quilon cooperative spinning mills,karamcode. It is approximately 50 meters away from the pulari travels. |
| 7 | 012-TCP | 685487.3 | 980254 | 6.447 | The survey station,012-SCP is marked with red and white paint and nail point on the top of the Panavel-Kochi-Kanniyakumari Highway BT road. The survey station is nearby National highway 66. It is approximately 100 meters away from the masjid. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 8 | 014-TCP | 683321.6 | 988575.8 | 15.586 | The survey station,014-SCP is marked with red and white paint and nail point on the top of the retaining wall on the side of the Kundara road. The survey station is nearby residential building,keralapuram. It is approximately 20 meters away from the electric pole. |
| 9 | 016-TCP | 684572.2 | 997523.8 | 28.520 | The survey station, 016-SCP is marked with red and white paint and nail point on the top of the concrete slab covering a Drinage on the side of the Kaithakode-Kallada BT road. The survey station is near by royal enterprises,othiramukah. It is approximately 5 meters away from the fancy store. |
| 10 | 017-TCP | 683888.7 | 1002183 | 33.862 | The survey station,017-SCP is marked with red and white paint and nail point on the top of the Kotteakara-Sasthamcotta BT road. The survey station is nearby happy mart super market,kunnathur. It is approximately 10 meters away from the electric pole. |
| 11 | 019-TCP | 681360.1 | 1011529 | 13.561 | The survey station,019-SCP is marked with red and white paint and nail point on the top of the village BT road. The survey station is nearby sree kandalasway temple,noonanad. It is approximately 30 meters away from the electric pole. |
| 12 | 021-TCP | 680638.8 | 1021020 | 8.847 | The survey station,021-SCP is marked with red and white paint and nail point on the top of the Kochalammoodu-Pandalam BT road. The survey station is nearby rubber garden,Ayranikudy village. It is approximately 10 meters away from the electric transformer. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 13 | 021_A-TCP | 681878.7 | 1026000 | 15.685 | The survey station,021_A-SCP is marked with red and white paint and nail point on the top of the Kottarakara-Kottayam BT road. The survey station is nearby bharath petrol station,kaaraikad. It is approximately 20 meters away from the ration shop. |
| 14 | 022_A-TCP | 679990 | 1028305 | 7.933 | The survey station,022_A-SCP is marked with red and white paint and nail point on the top of the Kottarakara-Kottayam BT road. The survey station is nearby Vayaloram resturant,mulakuzha. It is approximately 30 meters away from the rk vegetable shop. |
| 15 | 023-TCP | 679638.3 | 1037537 | 6.556 | The survey station,023-SCP is marked with red and white paint and nail point on the top of a Concrete slab on the side of the Cherukoipuzha-Kumbanad BT road. The survey station is nearby Araman Bakery. It is approximately 50 meters away from the Eraviperoor post office. |
| 16 | 024-TCP | 678809.3 | 1043217 | 10.802 | The survey station,024-SCP is marked with red and white paint and nail point on the top of the culvert. The survey station is on the Thituvall-Mallappally road. It is approximately 50 meters away from the electric pole. |
| 17 | 026-TCP | 677834.7 | 1044388 | 31.198 | The survey station,026-SCP is marked with red and white paint and nail point on the top of the Manthanam-Shanthipuram BT road. The survey station is nearby rubber garden,Kunnamthanam. It is approximately 20 meters away from the residential building. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 18 | 026_A-TCP | 677877.9 | 1049565 | 50.660 | The survey station,026_A-SCP is marked with red and white paint and nail point on the top of the Karukachal-Palamattam BT road. The survey station is nearby karukuchal palamattom road. It is approximately 50 meters away from the electric pole. |
| 19 | 027-TCP | 675583.9 | 1048378 | 29.026 | The survey station,027-SCP is marked with red and white paint and nail point on the top of the foot path for the Indian oil petrol bunk. The survey station is on the side of the Changannaserry BT road. It is approximately 5 meters away from the electric pole. |
| 20 | 027_A-TCP | 675560.9 | 1053289 | 15.298 | The survey station, 027_A-SCP is marked with red and white paint and nail point on the top of the Njaliyakuzhi-Thottackad BT road. The survey station is nearby thottakad bus stop. It is approximately 50 meters away from the electric pole. |
| 21 | 028_A-TCP | 674423.9 | 1055085 | 18.209 | The survey station,028_A-SCP is marked with red and white paint and nail point on the top of the Kottayam-Kozhencherry BT road. The survey station is nearby thivenehoor road. It is approximately 50 meters away from the electric pole. |
| 22 | 029-TCP | 669004 | 1057046 | 19.606 | The survey station,029-SCP is marked with red and white paint and nail point on the top of the Kollad-Devalokam BT road. The survey station is nearby gennesarath church. It is approximately 5 meters away from the electric pole. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 23 | 029_A-TCP | 672491.3 | 1060397 | 9.684 | The survey station,029_A-SCP is marked with red and white paint and nail point on the top of the Kottayam-Kumily BT road. The survey station is nearby kollam theni highway. It is approximately 5 meters away from the electric pole. |
| 24 | 030_A-TCP | 671922 | 1063515 | 5.802 | The survey station,030_A-SCP is marked with red and white paint and nail point on the top of the Eranjal-Thiruvenchoor BT road. The survey station is nearby residenttial building no: 34, chettipadi village. It is approximately 10 meters away from the provisional store. |
| 25 | 031-TCP | 671762.7 | 1066129 | 8.757 | The survey station,031-SCP is marked with red and white paint and nail point on the top of the Peroor- Ettumannur BT road. The survey station is nearby vechoor kavala bus stop,peroor. It is approximately 15 meters away from the Akshya centre. |
| 26 | 033-TCP | 670602.1 | 1073718 | 30.908 | The survey station,033-SCP is marked with red and white paint and nail point on the top of the Kannikamandabam Village BT road. The survey station is nearby MC road, Vempally. It is approximately 10 meters away from the residential building. |
| 27 | 034-TCP | 668612.1 | 1078832 | 29.715 | The survey station,034-SCP is marked with red and white paint and nail point on the top of the Pala-Vaikom BT road. The survey station is nearby pala vaikkam road. It is approximately 5 meters away from the electric pole. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 28 | 036-TCP | 664665 | 1085723 | 9.177 | The survey station,036-SCP is marked with red and white paint and nail point on the top of the culvert near the Kaduthuruthy-Peruva BT road. The survey station is nearby soda factory,kaduthuruthy. It is approximately 2 meters away from the electric pole. |
| 29 | 038-TCP | 659058.7 | 1095476 | 12.248 | The survey station,038-SCP is marked with red and white paint and nail point on the top of the Thiruvaniyoor-Maneed BT road. The survey station is nearby puthumlli residential building,maneed. It is approximately 10 meters away from the super market. |
| 30 | 039-TCP | 656706.6 | 1096426 | 50.376 | The survey station,039-SCP is marked with red and white paint and nail point on the top of the Vettikal-Pazhukamattom BT road. The survey station is nearby Saint Aphem church. It is approximately 5 meters away from the residential building. |
| 31 | 041-TCP | 650063.6 | 1105855 | 3.757 | The survey station,041-SCP is marked with red and white paint and nail point on the top of the tiled pavement on the side of the Smart city international BT road. The survey station is nearby brahmapuram mosque. It is approximately 50 meters away from the little gems international school. |
| 32 | 042-TCP | 651905.7 | 1108980 | 5.442 | The survey station,042-SCP is marked with red and white paint and nail point on the top of the Kakkanad-Pallikara BT road. The survey station is nearby kadamba river,manakkadavu. It is approximately 8 meters away from the electric pole. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 33 | 044-TCP | 651530.4 | 1119527 | 8.092 | The survey station,044-SCP is marked with red and white paint and nail point on the top of the Kalady-Aluva BT road. The survey station is nearby house,aluva road. It is approximately 15 meters away from the electric pole. |
| 34 | 045-TCP | 651197 | 1123616 | 8.622 | The survey station,045-SCP is marked with red and white paint and nail point on the top of the Retaining structure on the side of the village BT road. The survey station is nearby karyad-airport-mattoor road,nedumbassery village. It is approximately 5 meters away from the railway crossing. |
| 35 | 047-TCP | 646681.4 | 1129642 | 13.471 | The survey station,047-SCP is marked with red and white paint and nail point on the top of the Karakutty-Elavoor BT road. The survey station is nearby saint marys catholic church,kuviyakkulam village. It is approximately 8 meters away from the telephone pole. |
| 36 | 049-TCP | 641522.2 | 1136621 | 20.482 | The survey station,049-SCP is marked with red and white paint and nail point on the top of the Astamichira-Challkudy BT road. The survey station is nearby saint joseph school. It is approximately 5 meters away from the electric pole. |
| 37 | 051-TCP | 637803 | 1143548 | 11.685 | The survey station,051-SCP is marked with red and white paint and nail point on the top of the concrete slab on the side of the Moonupedika-Potta BT road. The survey station is nearby thommana lake. It is approximately 2 meters away from the sunrise saw mill shop. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 38 | 052-TCP | 635365.7 | 1148375 | 6.729 | The survey station,052-SCP is marked with red and white paint and nail point on the top of the bridge of the Mapparnam-Nandhikara BT road. The bridge is across the muriyad-moor canal. It is approximately 50 meters away from the electric pole. |
| 39 | 054-TCP | 632256.7 | 1157610 | 15.740 | The survey station,054-SCP is marked with red and white paint and nail point on the top of the Pallakal-Ammadan BT road. The survey station is nearby residential building,venginissery village. It is approximately 30 meters away from the rajesh complex. |
| 40 | 056-TCP | 630480.5 | 1168926 | 12.564 | The survey station,056-SCP is marked with red and white paint and nail point on the top of the Mundur-Kottakad BT road. The survey station is nearby K.A.lisson kolengadam house,kottekkad village. It is approximately 5 meters away from the telephone box. |
| 41 | 057-TCP | 628305.5 | 1170474 | 11.179 | The survey station,057-SCP is marked with red and white paint and nail point on the top of the Mundur-Kottakad BT road. The survey station is nearby edhan's bakery,mudur-kottekkad road. It is approximately 2 meters away from the well. |
| 42 | 059-TCP | 618731.5 | 1178432 | 15.842 | The survey station,059-SCP is marked with red and white paint and nail point on the top of the Kunnamkulam-Wadakkancherry BT road. The survey station is nearby bhaskara nivas house,chowannur. It is approximately 5 meters away from the electric pole. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 43 | 061-TCP | 613845.2 | 1186583 | 4.982 | The survey station,061-SCP is marked with red and white paint and nail point on the top of the culvert on the side of the Kunnamkulam-Thrissur BT road. The survey station is nearby emirates petroleum. It is approximately 10 meters away from the bus stop. |
| 44 | 063-TCP | 608761.1 | 1198714 | 9.625 | The survey station,063-SCP is marked with red and white paint and nail point on the top of the culvert on the Panavel-Kochi-Kanniyakumari BT road. The survey station is nearby panvel kochi kanyakumari highway name board. It is approximately 10 meters away from the tea shop. |
| 45 | 064-TCP | 604710.2 | 1203310 | 9.837 | The survey station,064-SCP is marked with red and white paint and nail point on the top of the Koloopalam-Mukkulapedika BT road. The survey station is nearby railway track. It is approximately 10 meters away from the fish shop. |
| 46 | 066-TCP | 598200.6 | 1210855 | 10.111 | The survey station,066-SCP is marked with red and white paint and nail point on the top of the railway footpath and is on the side of the Tharur-Thirur BT road. The survey station is nearby vattathani bus stop. It is approximately 42 meters away from the shadi bakery. |
| 47 | 067-TCP | 596144.2 | 1213993 | 6.817 | The survey station,067-SCP is marked with red and white paint and nail point on the top of culvert on the side of the Tanur-Velliyur BT road. The survey station is nearby railway track. It is approximately 120 meters away from the agricultural land. |
| 48 | 069-TCP | 593461.9 | 1222616 | 8.596 | The survey station,069-SCP is marked with red and white |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| | | | | | paint and nail point on the top of the Chamaravattan-Thirur-Kozhikode BT road. The survey station is nearby KM complex. It is approximately 50 meters away from the ayyappankavu bus stop. |
| 49 | 070-TCP | 591663 | 1228619 | 7.565 | The survey station,070-SCP is marked with red and white paint and nail point on the top of the Annangadi-Athanikal BT road. The survey station is nearby railway track. It is approximately 45 meters away from the fcacar accpssories shop and midsom hotel. |
| 50 | 072-TCP | 590113.4 | 1236853 | 15.081 | The survey station,072-SCP is marked with red and white paint and nail point on the top of the bridge of the Beypore-Cheruvannur BT road . The bridge goes over a railway track. It is approximately 50 meters away from the monotone hyper market. |
| 51 | 073-TCP | 586596.5 | 1240460 | 9.341 | The survey station,073-SCP is marked with red and white paint and nail point on the top of a concrete slab covering over a drainage and is on the side of the Callicut BT road. The survey station is nearby railway track. It is approximately 5 meters away from the ARE BEE chemicals. |
| 52 | 075-TCP | 583212 | 1248357 | 6.629 | The survey station,075-SCP is marked with red and white paint and nail point on the top of a concrete slab covering over a drainage and is on the side of the Bhatt road. The survey station is nearby sitara gents hostel. It is approximately 20 meters away from the electric pole. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 53 | 077-TCP | 579765.6 | 1258574 | 3.734 | The survey station,077-SCP is marked with red and white paint and nail point on the top of the Kappad-Thiruvangoor BT road. The survey station is nearby railway crossing. It is approximately 40 meters away from the shadi mahal. |
| 54 | 079-TCP | 574542.6 | 1266572 | 6.925 | The survey station,079-SCP is marked with red and white paint and nail point on the top of the Concrete slab covering a drainage on the side of the Panvel-Kochi-Kanniyakumari BT road. The survey station is nearby kollam railway crossing. It is approximately 5 meters away from the electric pole. |
| 55 | 081-TCP | 568793.2 | 1273661 | 2.098 | The survey station,081-SCP is marked with red and white paint and nail point on the top of the tiled pavement on the side of the Payyoli-Cheranndathur BT road. The survey station is nearby vegetable shop. It is approximately 20 meters away from the electric pole. |
| 56 | 082-TCP | 567810.4 | 1280974 | 10.821 | The survey station,082-SCP is marked with red and white paint and nail point on the top of concrete slab covering a drinage on the side of the Vattakara-thiruvallur-Perambara BT road. The survey station is nearby unitrun canteen. It is approximately 40 meters away from the shakthi auto mobile. |
| 57 | 084-TCP | 562724.1 | 1287620 | 11.379 | The survey station,084-SCP is marked with red and white paint and nail point on the top of the Madappally Railway BT road. The survey station is nearby PM complex. It is approximately 15 meters away from the electric pole. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 58 | 086-TCP | 559313.3 | 1296974 | 8.268 | The survey station,086-SCP is marked with red and white paint and nail point on the top of the concrete slab covering a drainage on the side of the Thalaserry-Nadapuram BT road. The survey station is nearby bar and restorent. It is approximately 3 meters away from the electric pole. |
| 59 | 087-TCP | 557791.4 | 1302566 | 18.185 | The survey station,087-SCP is marked with red and white paint and nail point on the top of the concrete slab covering a drainage on top of the Thalaserry-Coorg highway BT road. The survey station is nearby kadipur service bunk. It is approximately 15 meters away from the electric pole. |
| 60 | 089-TCP | 551658.5 | 1307356 | 13.778 | The survey station,089-SCP is marked with red and white paint and nail point on the top of theCheruvillayi BT road. The survey station is nearby vimalalayam house. It is approximately 15 meters away from the transformer. |
| 61 | 090-TCP | 546684.1 | 1309507 | 22.310 | The survey station,090-SCP is marked with red and white paint and nail point on the top of the Panvel-Kochi-Kanniyakumari BT road. The survey station is nearby railway track. It is approximately 20 meters away from the electric pole. |
| 62 | 091-TCP | 544367.6 | 1311735 | 6.557 | The survey station,091-SCP is marked with red and white paint and nail point on the top of the concrete slab covering a drainage on the side of the NH-17 BT road. The survey station is nearby bake'n'joy shop,kannur road. It is approximately 10 meters away from the bus stop. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 63 | 093-TCP | 537794.4 | 1318621 | 4.976 | The survey station,093-SCP is marked with red and white paint and nail point on the top of the concrete slab covering a drainage on the side of the Vazhapattinam-Azhikkal BT road. The survey station is nearby civil supply godown,valapattanam. It is approximately 10 meters away from the grama panchayat office. |
| 64 | 094-TCP | 534596.1 | 1324399 | 3.221 | The survey station,094-SCP is marked with red and white paint and nail point on the top of the concrete slab covering the drainage on the side of the Morazha-Kannapuram BT road. The survey station is nearby kannapuram-dharmasala road. It is approximately 20 meters away from the kannapuram railway crossing. |
| 65 | 096-TCP | 528935.4 | 1329765 | 5.112 | The survey station,096-SCP is marked with red and white paint and nail point on the top of the concrete slab covering the drainage on the side of the Payangadi-Payyannur BT road. The survey station is nearby eripuram junction. It is approximately 8 meters away from the my home show room. |
| 66 | 097-TCP | 525813.1 | 1333671 | 8.088 | The survey station,097-SCP is marked with red and white paint and nail point on the top of the village BT road. The survey station is nearby zahid store,kowapuram. It is approximately 5 meters away from the railway track. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 67 | 099-SCP | 519472.7 | 1340817 | 3.832 | The survey station,099-SCP is marked with red and white paint and nail point on the top of the concrete slab covering a drainage on top of the Payyannur-Kallikkad BT road. The survey station is nearby karolam masjid. It is approximately 15 meters away from the glow car washing and polish interior. |
| 68 | 100-SCP | 519064.8 | 1345656 | 5.936 | The survey station,100-SCP is marked with red and white paint and nail point on the top of the Chandhreaya-Thrikaripur-Olavara BT road. The survey station is nearby government homeopathy hospital,theru natakkvu village. It is approximately 8 meters away from the electric pole. |
| 69 | 102-SCP | 514888.3 | 1354728 | 7.159 | The survey station,102-SCP is marked with red and white paint and nail point on the top of the Service BT road. The survey station is nearby neeleshwaram railway station. It is approximately 50 meters away from the railway station bus stop. |
| 70 | 103-SCP | 512210.7 | 1356518 | 11.168 | The survey station,103-SCP is marked with red and white paint and nail point on the top of the footpath,Pandankkad flyoverof Panavel-Kanniyakumari Highway BT road. The survey station is nearby panvel-kanyakumari highway,pandankkad village. It is approximately 10 meters away from the speed limit signage. |

| Sl. No. | TCP No | EAST | NOTRH | Z (MSL) | Description |
|---|---|---|---|---|---|
| 71 | 105-SCP | 506614.2 | 1366964 | 15.633 | The survey station,105-SCP is marked with red and white paint and nail point on the top of the Kasargod-Kannur BT road. The survey station is nearby azeeziya arabic college. It is approximately 1 meters away from the traffic signal. |
| 72 | 107-SCP | 502587.2 | 1374609 | 12.111 | The survey station,107-SCP is marked with red and white paint and nail point on the top of the Edappally-Panavel BT road. The survey station is nearby puthiyaram bus stop. It is approximately 8 meters away from the railway track. |

Establishing Ground Control network in project site is among the most important activities as it controls the quality of the entire survey and data produced. The ground control established is also useful for the project executing authorities later in carrying out developmental activities in the project site.

### 6.9.4 Coordinate System for Project

#### 6.9.4.1 Coordinate systems

Coordinate systems enable geographic datasets to use common locations for integration. Project coordinate system is a reference system used to represent the locations of geographic features, Aerial imagery, LiDAR Point cloud data set and GNSS observations such as Ground control stations, Checkpoints within a common geographic framework.

Generally, a datum is a base to which all other values relate. Concerning the Earth, two datums exist: horizontal and vertical. A horizontal datum fixes a position on the Earth's surface related to the origin of latitude and longitude. On the other hand, a vertical datum provides a position concerning an elevation origin such as Ellipsoidal Height or Mean sea level height.

The following horizontal and vertical datums are proposed for LiDAR and aerial photo data collection and in later stages for post-processing the aerial surveyed data.

**Table 6-57: Horizontal and Vertical datums**

| | |
|---|---|
| Map Projection | Universal Traverse Mercator |

| | | |
|---|---|---|
| Zone | 43 N | |
| Horizontal Datum | WGS 84 | |
| Vertical Datum | Ortho Height | : Survey of India established MSL |
| | Ellipsoidal Height | : WGS- 84 |
| Units | Meters | |

#### 6.9.4.2 Horizontal Control Network

##### 6.9.4.2.1 Ground Control Survey Reference

The Ground control survey includes the establishing the project base station with reference the Survey of India known GCPs by 24 Hours observation or reference to the International GNSS Service (IGS) station by 72 Hours continuous observation. For further densification of Master control points network at every 25 km baseline length, the SoI/ IGS connected project base station will be considered as known control and densified with 1 hour 30 minutes' common time observation. The triangulation method will be adopted, and the loop closure accuracy acceptance threshold limit is 1:100000 or better. The secondary control point at every 5 km on the permanent structure will be observed concerning the MCPs with a common observation time of 45 minutes.

##### 6.9.4.2.2 DGPS for Horizontal Control :-

To establish the IGS network connection, Master Control Network, Secondary control Network and to Check Point Locations survey, the modern equipment with GNSS like Leica Viva GS14 has been deployed at the project site.

**6.9.4.2.2.1 Leica GNSS Receiver**:-

The Leica Viva GS14 deployed at site is a compact and powerful GNSS smart antenna, suited for any measuring task with integrated mobile communications and UHF modem. The Leica Viva GS14 is easy-to-use with its convenient and integrated design.

The Leica Viva GS14 is a powerful GNSS antenna which can access the four different GNSS constellations. It can function on two frequency channels simultaneously. It has the USB and RS232 serial ports to communicate with PCs. It contains the internal antenna for GSM/UMTS/CDMA phone modem. So, we can use those networks for communication as RTK DGPS during actual LiDAR survey.

Figure 6-26: Leica Viva GS14 GNSS Receiver

#### 6.9.4.3 Vertical Control Network

##### 6.9.4.3.1 Vertical Control Network Benchmark

The Vertical control network has been densified concerning the Survey of India known GTS Benchmark in reference to the Mean sea Level at every 25 km LiDAR target control points along the proposed corridor. The Double Territory Levelling method digital levelling has been employed at the site. The acceptance threshold limit for level loop closure accuracy maintained is 12 √K mm, where ‘K ‘ is in Kilometer. LiDAR data are most significant because of their ability to capture the vertical profile of terrain accurately and comprehensively. This is due to the high accuracy of LiDAR in the vertical dimension.

##### 6.9.4.3.2 Survey Equipment for Vertical Control

The Digital Level Instrument has been deployed at the site to carry out the vertical control transfer work. The digital level allows for precise levelling of both flat and gradient planes and performs tasks with much more precision, speed, competency and convenience as compared to using the traditional optical level. Also, measurement errors are reduced through digital readouts and the data collected could be transferred to other storage media conveniently via the accompanying software.

##### 6.9.4.3.3 Densification of Vertical Control in Field

The level transferring task was started from Survey of India established the GTS benchmark to benchmark by connecting every 25 km LiDAR target control points along the proposed survey corridor. These points has been used for Aerial LiDAR/GNSS

surveyed ellipsoidal height data into MSL. An example of Geokno team working in the field is shown in the below figures;

**Figure 6-277: Digital levelling work in the field**


**Figure 6-288: Levelling staff being observed during levelling operation**

### 6.9.4.3.4 Computation Strategy for Level Networks

Two methods are in general use; the "rise and fall" method and the "height of collimation" method. The "rise and fall" methods has been used for the reduction of all site levelling. The reduction may be carried out on-site before packing up to ensure that the levelling has been done correctly.

- Calculate the rises and falls between successive points and book them in the appropriate column (one can determine whether each shot is a rise or fall by the following rule of thumb: a higher value on top denotes a rise; a higher value on the bottom denotes a fall)

- Add up the back sight and foresight columns for the entire traverse and note the difference between them.

- Add up the rises and falls for the entire traverse and compare the difference between them with the difference between the back sights and foresight; they should be the same.

- The forward and backward loop will be framed from the two sets of DT Levelling reading and the loop closure has been checked. The acceptable threshold closing error limit has been maintained 12√k mm, where k is the loop length in a kilometer of the loops closed.

All levelling has been booked in either level books and retained as permanent records. Level books has been numbered so that they can be referenced on station history and inspection forms.

#### 6.9.4.3.5 Vertical Height Adjustment Procedure

The project deliverables requirement in terms of vertical datum reference is SOI-mean sea Level, whereas the ground-based GNSS surveying instruments and aerial -on board GNSS sensors will produce height concerning World Geodetic System 1984 (WGS84) datum.

In Aerial LiDAR Survey, the LiDAR point cloud is in the WGS-84 which is a geocentric and earth-fixed coordinates system and are expressed in terms of geodetic coordinates (i.e. latitude, longitude and ellipsoidal height) or Cartesian coordinates (i.e. geocentric X, Y and Z). In other words, the height value obtained by using Aerial Survey method is ellipsoidal height which is the height above the WGS84 reference ellipsoid rather than the orthometric height (or height above the geoid surface).

Since the data obtained is in reference with ellipsoidal height, the Generation of project deliverables concerning MSL heights has been computed by integrating the SoI proposed Geoid model.

In general surveying, measurements are made concerning the geoid which is the equipotential surface of the earth gravity and not the ellipsoid because the instrument is aligned with the local gravity vector, which is perpendicular to the geoid surface, normality using a spirit bubble. The geoid height or the geoidal undulation (N) is described as the separation of the geoid from the ellipsoid, as shown in Figure below;

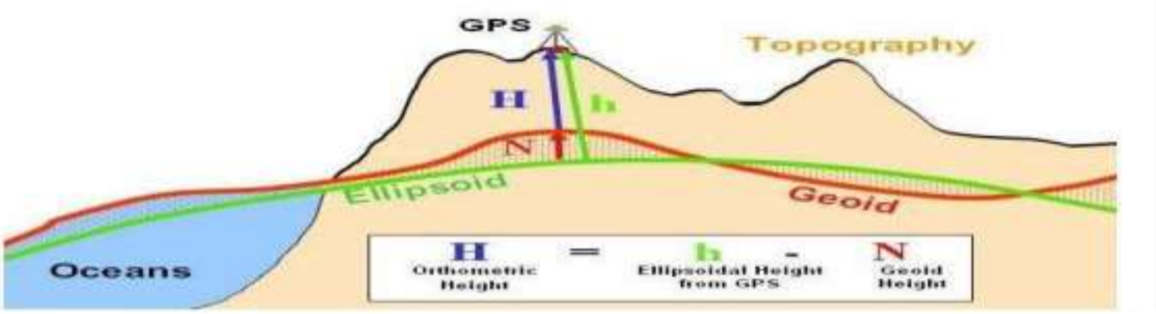



**Figure 6-2929: Earth Surface, Geoid, and Ellipsoid along with orthometric height**

Schematic representation of Earth Surface, Geoid, and Ellipsoid along with orthometric height, ellipsoidal height and Geoid height.

Consequently, ellipsoidal heights cannot satisfy the project requirement and must be transformed to orthometric heights (H). To accomplish this transformation between the ellipsoid heights and orthometric heights, the geoidal undulation (N) from the ellipsoid must be known. A WGS 84 ellipsoidal height (h) is transformed into an orthometric height (H) by subtracting the geoid – WGS 84 – ellipsoid separation (N) which is called the geoid undulation.

Depending on data availability and accuracy requirements, there are many principle approaches for determining Local Geoid models; some of the approaches are the gravimetric method, geometric method and the astrogeodetic method. The geometric method involves the use of GPS and levelling data, where both the ellipsoidal and orthometric heights are given. A mathematical relation depicting the surface of the geoid concerning the reference ellipsoid is known as a local geoid model.

N = hH H

All the primary control points geoidal undulation (N) will be calculated by using GNSS observed Ellipsoidal height and MSL value.

Project-specific Local geoid model will be developed by using the undulation value. This Local geoid model is supplied to Aerial survey team for adjusting the vertical height into MSL.

### 6.9.5 Approval of DGCA of LiDAR Aircraft To Fly For Capturing The Data

Necessary clearances from Director General of Civil Aviation including Ministry of Defense, Government of India, and other agencies have been obtained to complete the job of flying and capturing the data.

### 6.9.6 Flight Planning

The flight path is to cover the study area completely including enough cross flight lines to eliminate shadowing and allow for proper quality control. Flight line overlap is kept as 30% or greater as required to ensure that there are no data gaps between the

usable portions of the swaths. Data collections in high relief terrain to have greater overlap. Any data with gaps between the geometrically usable portions of the swaths are liable to be rejected.

Generally, missions during inclement weather which is known to degrade the accuracy of laser return data have been avoided. Documentation of mission date, time, flight altitude, airspeed, scan angle, scan rate, laser pulse rates, and other information deemed pertinent have been created.

Flight planning is a crucial aspect of Airborne Light Detection and Ranging (LiDAR) surveys to contribute to total Quality Assurance (QA) experience. Careful assessment of the requirements and planning with adequate timing is vital for successful mission completion.

Good Flight planning requires careful and extensive consideration of various phases of the project. Flight Planning have been carried out in such a way that, the flight line overlap will be 30% or greater to ensure that there are no data gaps between the usable portion of the swaths.

**Table 6-58: Flight planning technical specification**

| Description | Project Site |
|---|---|
| Altitude above the highest point | 150-900 m |
| Swath overlap | 20% |
| Pulse Rate | 400 kHz |
| Half Scan angle | 30 degrees |
| Aircraft speed | 110 knots |
| Resulting point spacing | 14 Points/$m^2$ |
| Project Required Point spacing | 10 Points/ $m^2$ |

### 6.9.7 Ariel Lidar Survey In 600m Width Along The Corridor

a) Principle of Aerial LiDAR Technology:

Light Detection and Ranging (LiDAR) technology collect high-accuracy elevation data for large areas very quickly and at a lower cost than traditional methods.

In LiDAR a Laser transmitter is used to throw a laser pulse, and a receiver is employed to detect the return of the pulse.

The ‘Time of flight’ is then calculated and since the speed of light is known, the distance of the point can be calculated. Normally, based on its requirement, LiDAR can be used on three platforms namely Terrestrial, Mobile, and Airborne.

The aerial LiDAR technology can acquire highly accurate and dense elevation data of terrain surface quickly and accurately with support of high-precision GPS and Inertial Navigation System as shown in below figure. Therefore, a high-precision Digital Terrain Model can be built from it.

A single pulse of LiDAR may reflect from multiple objects as different parts of the pulse cross-section may fall on different objects within a footprint.

This results in multiple returns thus recording multiple measurements corresponding to one pulse. This information provides an understanding of the vertical structure of objects like trees.

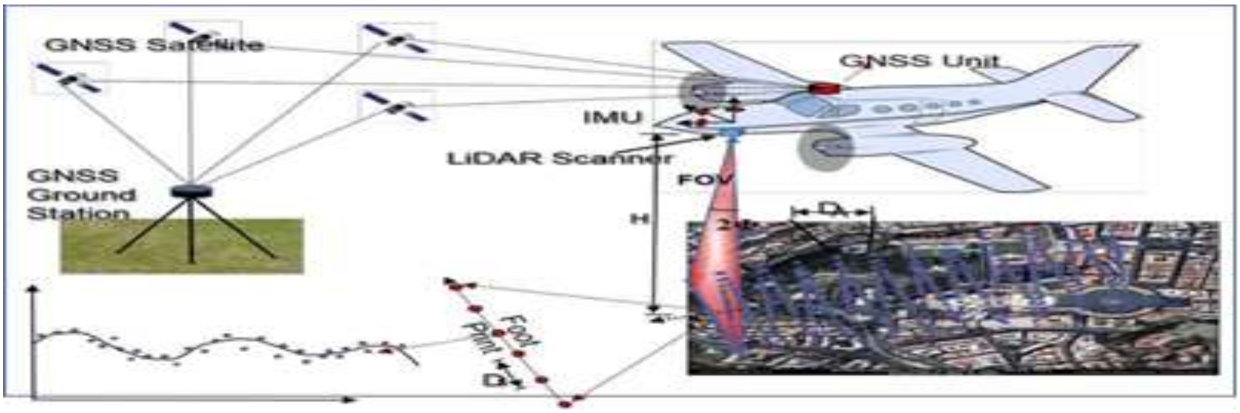



**Figure 6-30: Principle of airborne LiDAR Technology**

Aerial LiDAR system uses a combination of LiDAR equipment, GNSS unit for the position, Inertial Measurement Unit (IMU) for orientation and cameras for recording images (for coloring the output.)

The LiDAR unit is mounted on an aircraft/Helicopter as shown in the Figure 6-32. This is useful for large-area surveys such as irrigation, disaster mapping, flood mapping and corridor survey, alignment survey for irrigation canal and high-altitude roads.

These data is highly useful in planning and designing greenfield infrastructure projects for mapping large tracts of land, which are otherwise not accessible with conventional technologies.

**Table 6-59: Aerial LiDAR Data Specification**

| | |
|---|---|
| Data density | 10 Points / m2 |
| Operating Altitude | 150m - 900m |
| Fundamental Spatial | The fundamental spatial accuracy of the survey must conform to the following standard:<br>• Fundamental Vertical Accuracy (FVA) |

| | |
|---|---|
| Accuracy Requirements | <= +/- 10cm. 95% confidence interval<br>• Fundamental Horizontal Accuracy (FHA)<br><= +/- 15cm. 95% confidence interval |
| Horizontal Datum | The World Geodetic Datum 84 (WGS-84). |
| Map Projection | The coordinate system for all deliverables is Universal Transverse<br>Mercator (UTM). |
| Vertical Datum | Orthometric: All deliverables specified below as Orthometric will be referenced to the Survey of India Vertical Datum (MSL) – as determined by the published heights of local survey control marks within or adjacent to the project extent.<br>Ellipsoid: All deliverables specified below as ellipsoidal will be in terms of the WGS-84reference frame. The source of the ellipsoidal height control shall be<br>explained in the 'Post-Survey Spatial Accuracy Report'. |
| Local Datum | To convert the LiDAR data to MSL, Local datum should be developed. |

| | |
|---|---|
| Collection Requirements | Recording a minimum Nominal Post Spacing (NPS) of 0.25 m<br>outbound pulses per square meter<br>A scan angle not exceeding 40˚ Total FOV (+/- 20˚ from nadir)<br>An across/along-track point spacing ratio not exceeding 2/3.<br>Flight line overlap must be 30% or greater, as required to ensure<br>that there are no data gaps between the usable portions of the<br>swaths.<br>Data Voids (with void areas more than and equal to 4xNPS),<br>measured using 1st-returns only within a single swath are not<br>acceptable, except:<br>where caused by water bodies<br>where caused by areas of low near infra-red (NIR) reflectivity<br>c) where appropriately filled-in by another swath<br><br>6. The spatial distribution of geometrically usable points should be<br>uniform and free from clustering.<br>7. Environmental conditions for data capture are:<br>a) Cloud and fog-free between aircraft and ground.<br>b) Flights would not be undertaken during periods of heavy smoke,<br>haze and rain.<br>c) Preferably, during leaf-off season<br>8. Every effort shall be made to avoid breaks within individual flight<br>lines. Where breaks within a flight line are necessary, the entire<br>flight line composed of the resulting segments shall meet all the<br>requirements outlined in specifications. |

**Table 6-60: Aerial Photograph Specification**

| | |
|---|---|
| Ground Sampling Distance (GSD) | 10 cm |
| Bands | R G B (Three bands natural color imagery) |
| End overlap | 60% minimum |
| Side overlap | 30% minimum |
| Collection condition | Same as LiDAR with following additional conditions:<br>• Sun angle no less than 30 degrees to minimize shadow<br>• The project site has high relief changes, therefore, the photograph should be<br>captured at high sun angle to avoid shadows due to this high relief<br>formations.<br>• Cloud free (at least 95% cloud-free) with minimal smoke, smog and dust.<br>• Every effort shall be made to avoid breaks within individual flight lines.<br>Where necessary, the entire flight line composed of the resulting segments<br>shall meet all the requirements outlined in these specifications. Where<br>breaks occur, these shall have an overlap of at least four frames to ensure stereo model of overlap or tie. |
| Image Format | Uncompressed GeoTiff |
| Imagery Product | The seamless mosaic covering the project area and non-overlapping, edge- matched tiles. |
| Radiometric Resolution | Minimum 8 bit per band following the chosen image format |
| Horizontal Accuracy | 10cm GSD or better for the ortho-photo generated. |
| Vertical Datum | Orthometric: All deliverables will be referenced to the Survey of India Vertical Datum (MSL).<br>Ellipsoid: Also, all deliverables will be referenced to the WGS-84 reference frame. The source of the ellipsoidal height control shall be explained in the “Post-Survey Spatial Accuracy Report”. |

| | |
|---|---|
| Horizontal Datum | The World Geodetic Datum 84 (WGS-84). |
| Map Projection | The coordinate system for all deliverables is the Universal Transverse Mercator (UTM). |

### 6.9.8 Data Processing to Develop the GAD Plans and other Reports and DTM Data

The agency deployed to provide high-resolution, high-accuracy, "bare-earth" ground elevation data at regular spacing (DEM), irregular spacing with mass points and break-lines (DTM), and the elevation data of all top surfaces (DSM). To restrict data to ground elevations only, the agency has to remove elevation points on bridges, buildings, and other structures and vegetation, from the LiDAR-derived data. In addition to randomly spaced LiDAR points, before and after removal of data associated with structures and vegetation, it is must to produce a bare-earth DEM. it is must to use Triangular Irregular Network (TIN) linear interpolation procedures, including brake lines, when validating the vertical accuracy of the data models.

Post Processing has been done for 100m wide corridor i.e. 50m on either side of the centerline of the alignment. In the case of river/stream, it has to cover 50m beyond high bank/HFL. If there is a requirement of re-alignment, the contractor shall do additional post-processing to provide the stipulated outputs has been done.

### 6.9.9 AERIAL LiDAR DATA SECURITY

The work of LiDAR survey has been done as per security procedures and approvals of the Govt for the security of the data captured during flying. Security configuration management as followed provides an important function for secure processing, storing and transmitting information in safe environment establishing and maintaining secure information system configurations and provides support for managing risks in information systems.

**Security proceedings undertaken during study of the project for LiDAR survey :-**

- MoD was approached and MoD issued no objection for Aerial LiDAR Survey vide letter no: 20(38)/2019/D(GSIII) dated 17th Oct 2019.
- Then DGCA permitted to carry out Aerial LiDAR Survey for Thiruvananthapuram – Kasaragod Semi-High-Speed Rail Corridor vide letter no: 8-59/2019-IR dated 24th Oct 2019.
- A joint inspection of Survey aircraft and on-board survey equipment/sensors was carried out by representative of IB/MHA, AHQ/Mil Svy (GSGS) and Air HQ at New Delhi airport before the commencement of the task.

- After the inspection of aircraft & equipment, the security inspection team of MoD handed over the task of on board security officer to an officer from KRDCL, who later performed the task of on board Security officer for all flying during the survey and ensured adherence of DGCA and MoD security instructions for safe custody of collected data.
- Aerial Survey at Kochi was undertaken with respect to air traffic in consultation with HQSNC/CAVO and commander (Air) /INS Garuda.
- Aerial Survey in the proximity of Vas/VPs were undertaken in consultation with HQSNC/CIO.
- The Survey was strictly carried out around the geographic co-ordinates provided & cleared by MoD.
- Standard laid down Air Defence procedures were followed, while undertaking the Aerial Survey.
- Since the area falls within the restricted Zone i.e., within 25km from IB. Only Indian pilots were used during flying.
- The flying operator obtained prior clearance from Civil ATS/Defence ATS for using their airspace.
- The entire survey task was conducted under the strict supervision of onboard Security officer as indicated in the permission letter.
- The security officer ensured adherence of security instruction of DGCA/MoD and also ensured safe custody of collected data till the date of security vetting by MoD/TB(MHA).
- At the end of each day operation, the data tapes/disks were to be removed and kept at a secured place in the presence of Security Officer. The data and survey equipment's were password protected.
- On the day of completion of task, no data was to be left in the storage media. It was to be totally wiped out followed by multiple formatting in the presence of Security Officer.
- Pre-processing of data to facilitate security vetting was carried out at Survey of India, Director Survey (Air) & Delhi Geo-Spatial Data Centre, 2nd Floor, Wing-IV, West Block No.4, R K Puram, New Delhi on 27/01/2020. A copy of data was handed over to the same office for security vetting.
- The cover plots and actual flight path overlaid on OSM maps in .shp file format was handed over to ADG Military Survey (GSGS), DGIS Enclave, 2nd Floor, Rao Tula Marg, New Delhi for security vetting.
- The task number, which is a pre-requisite for security vetting was acquired on 26/11/2019 with task number T-1788/51-E(SV) from SoI.
- Security vetting/clearance of the Aerial LiDAR data was completed on 04/02/2020.
- The security vetted data was handed over to security officer in charge and used for project purpose only.

- To ensure the safety of the data, a copy of data was stored in external Hard Drives and high end servers before starting the post processing works.
- The post processing works were carried out in most restricted and secured environment.
- The data deliverables were stored in the HDD's perpetually to study the temporal changes of the project area.
- Project data backup were taken by the Infrastructure (Network & System Admin) team as per the Infrastructure back up policy of the GeoKno, if there is any transition in the IT network in future.

### 6.9.10 Site verification and Collection of other Filed Data

Site verification with Quality Control/Quality Assurance (QC/QA) of the LIDAR and/or LiDAR-derived plan has been done by deploying the experts to check the quality of the work done.

### 6.9.11 Detailed Topographical Survey Report

In this DPR only abstract of the survey report has been included, more details about complete descreption of the LiDAR survey is included in separate volume at Volume No IV Part B.

# DETAILED PROJECT REPORT

## SEMI HIGH SPEED RAIL CORRIDOR
## THIRUVANANTHAPURAM TO KASARAGOD

## VOLUME II - MAIN REPORT
## (PART B)

## CHAPTER 7
## STATION & AREA DEVELOPMENT

# 7 STATION & AREA DEVELOPMENT

The purpose of this chapter is to document

(a) station typologies and conceptual design of individual stations that lie on the proposed Thiruvananthapuram-Kasaragod corridor (SilverLine)

(b) the proposed Urban Design of select station precincts and

(c) the proposed transit oriented development (TOD).

This chapter also describes the guiding principles and development parameters that should be considered while developing the sites and stations along the aforementioned SilverLine corridor. This chapter documents the architecture, planning and urban design approach based on the considerations of accessibility, multimodality, traffic and availability of public amenities in the immediate context of the stations in the corridor.

Moreover, it is highly expected to exploit the potential of SilverLine corridor by developing the stations and area around the stations by connecting smoothly with other transport modes at the SilverLine station and develop the around station area based on TOD (Transport Oriented Development). The SilverLine station area has huge potential to be a hub of not only SilverLine passenger's but other non-railway related user's activity. Station configuration addresses the geometry and functional needs of the station design. Station configuration issues involve the design of station entrances, the arrangement of the train platform(s), the location and relationship of the fare control area(s) with reference to the entrance(s) and platform(s), parking facilities, work and rest areas, and the integration of ancillary and support facilities with the public functions.

Station designers are required to adopt a guiding set of principles that establish the design priorities for the project. These guiding principles should be clearly expressed and easily communicated such that the most important aspects of the design can be defended and protected against future encumbrances.

Figure 7-1: Image of Station Buildings

## 7.1 DESIGNING PRINCIPLES OF STATION & AMENITIES:

Some more principals can be taken from below,

(1) Safety and security
(2) PPM targets and reliability
(3) Inclusiveness and accessibility
(4) Capacity and future proofing
(5) Intermodal exchange and wayfinding
(6) Whole life cost and operation
(7) System Approach
(8) Sustainability
(9) Urban integration
(10) Retail, social and business
(11) Standardised approach
(12) Passenger experience and delight

## 7.2 STATION TYPES

### 7.2.1 Line Stations

Line stations lie between the terminal ends of the tracks. Line stations predominantly serve passengers destined to or bound from the station's immediate catchments area. Passenger flows at line stations tend to be bi-directional, depending on demand characteristics. Design considerations may include:

(i) Accommodation of peak passenger movements

(ii) Accommodation of staff facilities
(iii) Accommodation of commercial developments.

### 7.2.2 Terminal Stations

Terminal stations are located at the end of the Railway line network and tend to have significant inter-modal transfers. Terminal stations tend to serve passengers from beyond the immediate station catchment area. Commuter Passenger flows at terminal stations tend to be unidirectional according to morning and evening peak passenger demands. In case of Long-Distance trains at the Terminal Station, the Passenger flow is equally spread over the day. Design considerations shall include among others:

(i) Accommodation of large peak passenger movements associated with terminating trains.
(ii) Inter-modal transfer to transit and non-transit modes (e.g., bus, auto).
(iii) Park-and-ride, kiss-and-ride facilities.
(iv) Accommodation of storage tracks and maintenance facilities.
(v) Accommodation of staff facilities.
(vi) Accommodation of Commercial developments.

### 7.2.3 Transfer Stations

Transfer stations connect different railway lines and stations and are subject to large transfer passenger flows. Transfer connections are typically made via passageways and VCEs connecting other areas of the station and platforms. Passenger transfers should be made within the paid areas of stations. Design considerations may include the following:

(i) Utilizing moving walkways to assist customers and reduce travel time over long (> 153 m) distances.
(ii) Providing an accessible transfer between station platforms (Handicap Accessibility section).
(iii) Providing emergency egress along the transfer route as required by NFPA (National Fire Protection Association) and the National Building Code.
(iv) Safety and security, including unobstructed sightlines.
(v) Transfer concourses and passageways.
(vi) Difficult transfers, which may require extensive Constructions.

### 7.2.4 Inter-Modal Stations

Inter-modal stations provide connections from the SilverLine stations to other modes of public transportation including bus, Indian Railway, light rail transit, people movers, and metro transit systems. Design considerations may include:

(i) Accommodation of large numbers of passengers with baggage.

(ii) Accommodation of large peak passenger movements associated with other modes.
(iii) Moving walkways (travellators) to assist customers and reduce travel time over long (i.e., > 150 m) distances.
(iv) Development of large transfer halls (the hub of the inter-modal facility), ticketing facilities and waiting areas.
(v) Connections that may require extensive renovation to existing facilities.
(vi) Connections that may require extensive renovation to existing inter- modal facilities.

**Figure 7-2: Façade Image of the Silver line Station**

## 7.3 DESIGN OF STATION BUILDING

(i) The main building will be designed to reflect the local culture and traditional art with functional orientation of all the amenities.
(ii) The platforms shall be visible from the concourse and waiting area for the convenience of passengers.
(iii) Quick transit of passengers with minimum walking distance to save time.
(iv) Free flow of passengers without cross movements and streamlined baggage handling.
(v) Area and volume required to have aesthetic architectural features are designed based on National Building Code of India and other Indian standards applicable.
(vi) Capacity analysis and required element identification have to be carried out in consonant with the following.
   a) Overall station – Design year horizon average peak day.
   b) Concourses – Based on analysis of maximum number of trains alighting and detraining at peak operation (may vary depending on extent of transfer activity).
   c) Circulation elements - The maximum throughput established for each passenger circulation element (The emergency egress requirements of the station as determined by the requirements of

NFPA 130 and 101).

d) Entrance/Egress – Peak hourly load as determined by analysis (minimum of 10% of average peak daily capacity).

e) Platforms – Peak hour train discharge as determined by analysis (Central platform should have capacity to discharge minimum two full capacity train and Side platform should have capacity to discharge minimum one full capacity train at a time.).

f) Amenities - Based on analysis of maximum number of trains alighting and detraining at peak operation (may vary depending on extent of transfer activity) and passenger profile.

g) Service standards – Any requirement established to clear the platform of arriving passengers within a given length of time after the train arrives for performance, operational, or other reasons.

**Figure 7-3: Image of a Windscreen**

### 7.3.1 GENERAL DESIGN FEATURES

General design shall cater to the movement /circulation of passengers for arrival/departure at this station. A schematic diagram is indicated below for general guidance during detailed design.

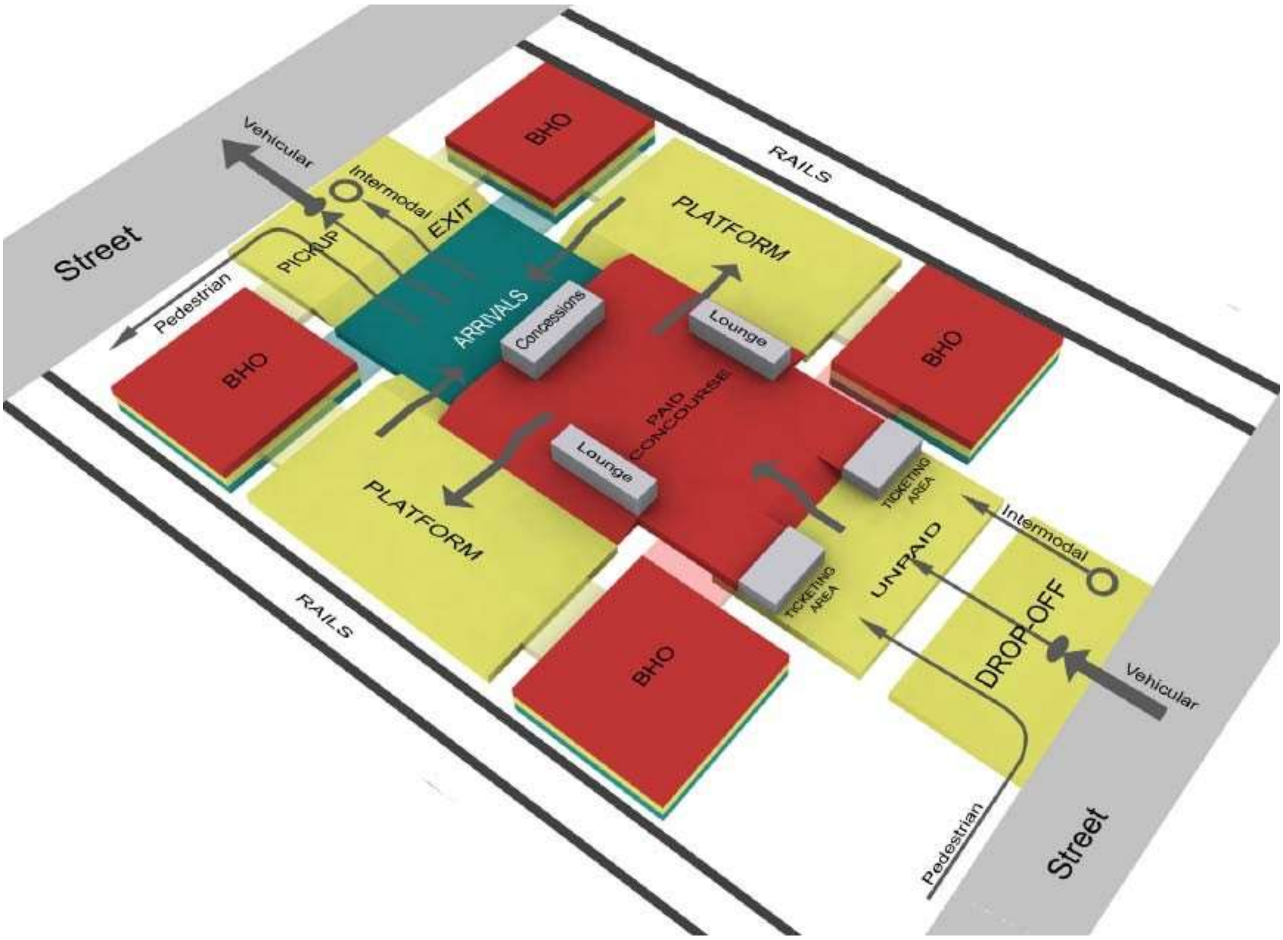



**Figure 7-4: Schematic diagram showing Passenger Circulation Flow within the Station**

## 7.4 DESIGN OF PLATFORMS

Length of the platforms had been kept as 410m so as to have 5m extra length on both sides of the front and rear passenger car/loco of the train that departs or arrives at the particular station platform. However, over the second loop where only feeder trains will be dealt with, platform length shall be 400m. Width of the platform is designed to be as under.

(i) Platform width - Double sided - Island PF width of 11.32m
(ii) Minimum width of 9m at all locations and 5m at either end.
(iii) Direct across platforms of width 5m at all locations and 4m at either end.
(iv) Height of the platform shall be 1250mm from rail top.

## 7.5 STATION FACILITY FOR PASSENGERS

### 7.5.1 Elements of Station Facility

(i) Building entrance - Booking windows, Ticket gates, drinking water, Toilets etc., with all Safety & signages
(ii) Passage /Way - Subways, Foot over bridges, concourse etc., with all Safety & Signages.
(iii) Platform - Wider platform, aesthetic roof, windscreen, Communication System etc. with all Safety & signages.
(iv) Electrical - Lighting, Escalators, Lifts, Travellators etc. with all Safety.
(v) Other facilities - Fire prevention equipment, Security system etc.


**Figure 7-5: Image of Ticket Counters**

### 7.5.2 Means for Efficient Movement of Passengers

Strategies to facilitate the free flow of passengers shall include, but not be limited to the following,

(i) Separation of different categories of passengers.
(ii) Design of a clear, simple, and direct passenger circulation system, minimizing turns and decision points.
(iii) Minimizing travel distances.
(iv) Efficient and strategic use of VCEs.
(v) Efficient and strategic use of electronic boards to display information about train schedules, etc.

(vi) Minimizing crossflows and conflicting passenger movements.

#### 7.5.2.1 Customer satisfaction, Comfort, and Convenience (3 Cs in conceptual design)

The designer shall focus on customer service including, but not limited to the following:

(i) Minimizing travel distance between the station entrance and the train.
(ii) Providing assisted locomotion (i.e., elevators, escalators, moving walkways, equipment for the physically challenged, e.g., wheelchairs).
(iii) Providing a clear and logical customer circulation system.
(iv) Minimizing turns in passengers movements..
(v) Avoiding obstructions to passengers movement.
(vi) Minimizing pedestrian conflicts and crossflows.
(vii) Providing adequate customer amenities to accommodate customer needs.
(viii) Providing an acceptable Level of Service (minimum LOS C) to ensure a minimum degree of passenger comfort.
(ix) Information centre.
(x) Ticketing service.
(xi) Passenger waiting areas.
(xii) Passenger toilet facilities (men/women/handicapped).
(xiii) Stores, shops, food stalls/restaurants.
(xiv) Providing potable water at the platforms, in addition to the station facility.
(xv) Providing a comfortable environment with respect to acoustic, thermal, lighting and air quality.

## 7.6 OVERALL DESIGN CONCEPT – MODULES IN STAGES

Initially only the minimum area in consonant with the functional requirement and amenities are programmed to be constructed. Modular construction concept has been built to enable extension in phases for future extension and expansion based on passenger demand. Two aspects in modular design, namely consistency to enhance way & visual clarity and the consistency in station elements shall be applied.

## 7.7 DESIGN PARAMETERS FOR LARGE STATIONS

### 7.7.1 Layout of Station

Station building to be positioned at an appropriate site to have a direct view and to have multi model integration at the entry points. Spatial modelling shall cater to the environment, links to convenient movement of passenger’s easy access from approach roads etc.

### 7.7.2 Signages

Signages are the most visible station elements and are essential to passengers and for navigation of the system. Signages in brief

(i) Provides guidance to passengers.
(ii) Service information Providers.
(iii) Help in way finding process.
(iv) Details the level of amenities/services available.

#### 7.7.2.1 Types of signage

##### 7.7.2.1.1 Fixed /Static signage

Contains information of permanent /unchanging type such as station name, direction & destination, Entry /Exit points

(i) Located at exterior and showing direction of ticket window, amenities, platforms, elevations etc.
(ii) At platform showing concourse, other platforms, multimodal connections, egress etc.
(iii) Identification sign such as ticket window, Entry/Exit etc.

##### 7.7.2.1.2 Variable or Dynamic signage

Information content varies and forms integral part of train information system.

(i) Located in exterior & at departure concourse.
(ii) Reservation / Availability of seats.
(iii) Time of Arrival /Departure of trains.

#### 7.7.2.2 Train Information Display

The train information display shall contain

(i) Train Number/ID
(ii) Route
(iii) Track/Platform Number
(iv) Current station
(v) Expected and Actual Arrival/Departure Time

#### 7.7.2.3 Station information Centre

(i) Route Map
(ii) Intermodal Connections

#### 7.7.2.4 Help Point Intercom

To work on wireless system and to be used both during normal times for service and during emergency by public.

### 7.7.3 Entry and Exit Points

Widen entry and exits for free movements of passengers, luggage's, wheelchair etc shall be made with access and agrees routes along with fire/emergency provisions. For maintenance, security, emergency staff etc., also, adequate passages shall be provided.

### 7.7.4 Crowding and Control of Peak Hour Traffic

All the design measures to be adopted are based on peak hour passengers being dealt with. Adequate number of booking counters, security gates, etc. shall be installed to avoid large queue and crowd at any location and at any time of the day including morning and evening peak hours.

### 7.7.5 Parking and Premium Parking Lots

Park and ride facilities at SilverLine stations are essential since SilverLine provides for faster day journey and to meet with the needs of daily commuters. Parking space shall be as close to the main entry gate, to the extent possible.

### 7.7.6 Passenger Amenities

Toilets, Potable drinking water and other following amenities as per the yard stick are proposed to be provided at both the concourse area and paid area at platform.

(i) Toilets
(ii) Lounges and Cafes
(iii) Concession stands for retail and food
(iv) Vending machines
(v) Waiting room furniture (reserved/unreserved)
(vi) Lounge furniture
(vii) Platform furniture
(viii) Ticket/inquiry booths
(ix) TVM's
(x) Trash receptacles
(xi) Counters
(xii) Public telephone
(xiii) ATM's
(xiv) Station Information Centers

(xv) Public Security Stations

Figure 7-6: Image of Paid Concourse

## 7.8 LEVEL OF SERVICE (LOS) PERFORMANCE STANDARDS REQUIRED

LOS performance standards a mentioned in table 7-1, provide a method of sizing passenger circulation elements that respond to the demands of pedestrian behaviour based on John J. Fruin's Pedestrian Planning and Design (1987). The capacity of passenger circulation elements shall permit natural, free-speed passenger movement and consider the physical dimensions of the human body and human locomotion. A LOS of C or greater as per table 7-1 shall be used for all passenger circulation elements based on the projected passenger/ridership load target. However, station design shall take into account seasonal peak use and ensure that all station components conform to a Level of Service (LOS) D as per table 7-1 during this period. The following charts outline the LOS requirements of various station elements. In design of certain facilities, where J.J Fruin standards are not applicable World Class Railway Station standards developed by MoR/ GoI shall apply.

### 7.8.1 Level of Service Standards (LOS) prescribed are as below:

Table 7-1: J.J Fruin's Queue LOS

| LOS | Description | Sq. m. per Person |
|---|---|---|
| A | Free circulation zone | 1.17 or more |
| B | Restricted circulation zone | 0.9 -1.17 |
| C | Personal comfort zone | 0.63 -0.9 |
| D | No-touch zone | 0.27 – 0.63 |
| E | Touch zone | 0.18 – 0.27 |

| LOS | Description | Sq. m. per Person |
|---|---|---|
| F | Body ellipse | 0.09 or less |

**Table 7-2: Circulation flows as per J.J Fruin's Queue LOS**

| LOS | Avg. Ped. Space $M^2/p$ | Flow per Unit Width (p/m/min) | Description |
|---|---|---|---|
| **A** | >1.9 | <16 | Standing and free circulation through the queuing area possible without disturbing others within the queue. |
| **B** | 1.4-1.9 | 16-23 | Standing and partially restricted circulation to avoid disturbing others within the queue is possible. |
| **C** | 0.9-1.4 | 23-33 | Standing and restricted circulation through the queuing area by disturbing others is possible; this density is within the range of personal comfort. |
| **D** | 0.7-0.9 | 33-43 | Standing without touching is impossible; circulation is severely restricted within the queue and forward movement is only possible as a group; long-term waiting at this density is discomforting. |
| **E** | 0.4-0.7 | 43-56 | Standing in physical contact with others is unavoidable; circulation within the queue is not possible; queuing at this density can only be sustained for a short period without serious discomfort. |
| **F** | <0.4 | Variable | Virtually all persons within the queue are standing in direct physical contact with others; this density is extremely discomforting; no movement is possible within the queue; the potential for pushing and panic exists. |

**Table 7-3: Allocated Space per Person in the Terminal Area**

| Terminal Area | Allocated square meter per person | | | | | |
|---|---|---|---|---|---|---|
| **LOS** | **A** | **B** | **C** | **D** | **E** | **F** |
| **Check-in Queue** | 1.71 | 1.53 | 1.35 | 1.17 | 0.99 | System |

| Terminal Area | Allocated square meter per person | | | | | |
|---|---|---|---|---|---|---|
| LOS | A | B | C | D | E | F |
| Wait/Circulate | 2.61 | 2.25 | 1.8 | 1.44 | 0.99 | breakdown |
| Hold room | 1.35 | 1.17 | 0.99 | 0.81 | 0.54 | |

Source : IATA (International Air Transportation Association

## 7.9 LAYOUT OF STATION & CONCOURSE


**Figure 7-7: Indicative image of Commercial Zone in the Free Concourse Area**

Elegant station design forms the new landmark in the city/town with aesthetic features. Station square is also to be designed to match with the layout of buildings. Entry/Exit to stations are designed for having easy and convenient access into and from the station. The station buildings are designed to create “Delight when enter and Regret when depart”.

**Table 7-4: Concept followed in SilverLine Stations**

| Sl. No. | Station Description | Locations |
|---|---|---|
| 1 | Platforms at ground floor and concourse at first floor. | Kollam, Chengannur, Kottayam, Tirur, Kannur, Kasaragod. |
| 2 | Platform at elevated floor and concourse at ground floor & Upper floors. | Thiruvananthapuram (Kochuveli), Ernakulam & Trissur |
| 3 | Both Platforms & concourse at underground floor. | Kozhikode |

### 7.9.1 Station Structure - Typical

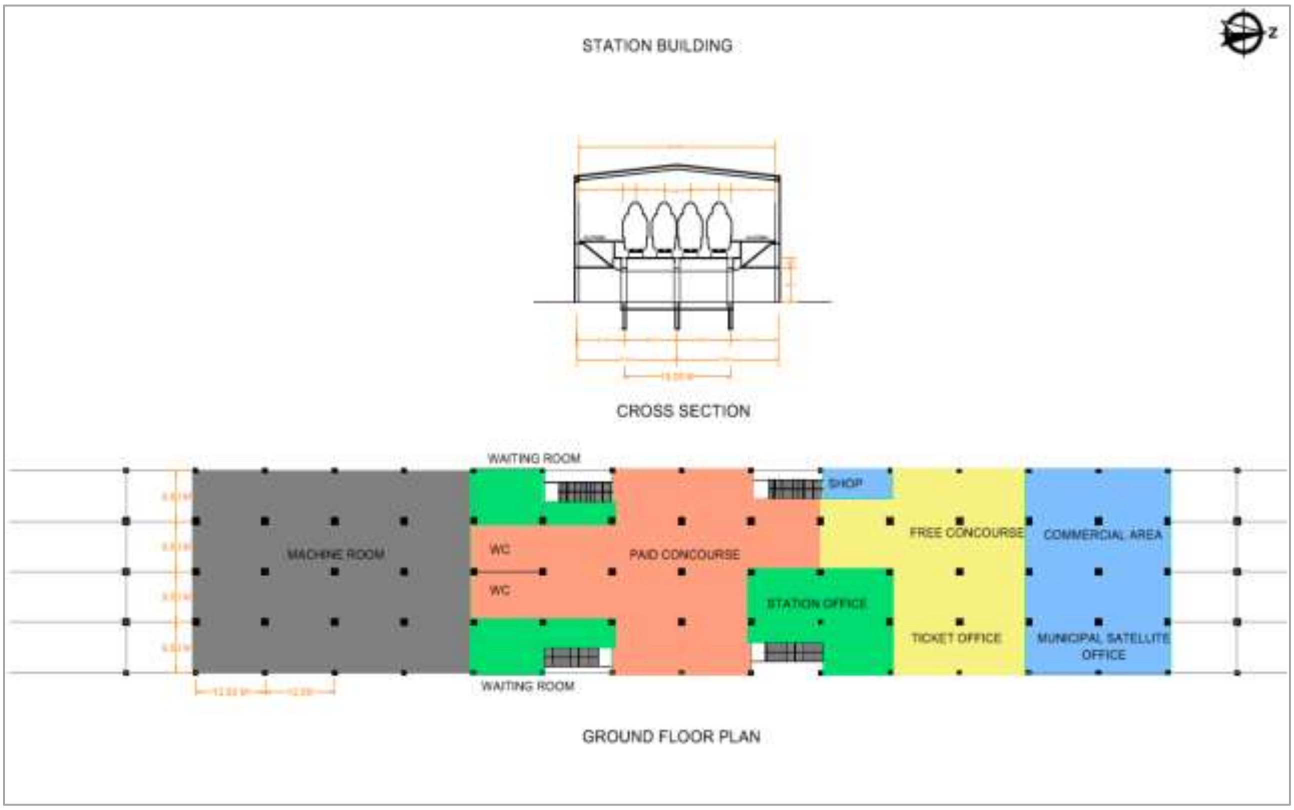



**Figure 7-8: Typical Station Structure**

**Table 7-5: Type of Supporting Structures**

| Station Name | Platform | Type | Building | Future |
|---|---|---|---|---|
| Thiruvananthapuram (Kochuveli) | • 3 Island Platforms 410m long & 11.32 m wide.<br>• 1 Island Platforms 410m long & 11.32 m wide (for future).<br>• 1 Platform 400 m long & 11.32 m wide. | RC framed structure and temporary roof using galvalume sheets on top. (For future upward expansion) | 12 bays (Each bay 12.5m long and 87 m wide in Phase-I) | |
| Kollam | • 3 Island Platforms 410m long & 11.32 m wide.<br>• 1 Island Platform 400m long & 11.32 m wide.<br>• 1 platform 400 m long & 10 m wide. | Framed structure and temporary roof using galvalume sheets. | 8 bays (Each bay 12.5m long) | |
| Kollam Depot | • Inspection Bay Line (IBL)- 2 Platforms 400m long & 3.0m wide<br>• Stable Bay Line (SBL)- 7 Platforms 410 m long & 3.0m wide | Industrial roof | | |
| Chengannur | • 2 Island Platforms 410 m long & 11.32 m wide. | RC framed structure and temporary roof using galvalume sheets. | 6 bays (Each bay 12.5m long) | |

| Station Name | Platform | Type | Building | Future |
|---|---|---|---|---|
| Kottayam | • 2 Nos Island Platforms 410 m long & 11.32 m wide.<br>• 1 No tourist siding platform 5m wide and 350m long. | Framed structure and temporary roof using galvalume sheets. | 8 bays (Each bay 12.5m long) | |
| Ernakulam | • 2 Island Platforms 410m long & 11.32 m wide.<br>• 2 Island Platforms 400m long & 11.32 m wide.<br>• 1 Platform 400 m long & 11.32 m wide. | Framed structure and temporary roof using galvalume sheets. | 12 bays (Each bay 12.5m long) | |
| Thrissur | • 2 Island Platforms 410m long & 8m wide11.32 m wide.<br>• 2 single Platforms 350m long & 11.32 m wide. (for future) | Framed structure and temporary roof using galvalume sheets. | 8 bays (Each bay 12.5m long) | |
| Tirur | • 2 Island Platforms 410m long & 11.32m Wide. | Framed structure and temporary roof using galvalume sheets. | 6 bays (Each bay 12.5m long) | |
| Kozhikode | • 2 Island Platforms 410m long & 11.32m wide. | Framed structure and temporary roof using galvalume sheets. | 12 bays (Each bay 12.5m long) | |

| Station Name | Platform | Type | Building | Future |
|---|---|---|---|---|
| Kannur | • 2 Island Platforms 410m long & 11.32m wide. | Framed structure and temporary roof using galvalume sheets. | 8 bays in Phase-I (Each bay 12.5m long) | |
| Kasaragod | • 2Nos Island Platform 410m long & 11.32m wide.<br>• 2 Nos Island Platforms 410 m long & 11.32m wide.<br>• 1 No single Platform 400m long & 10m wide. | Framed structure and temporary roof using galvalume sheets. | 8 bays (Each bay 12.5m long) | |
| Kasaragod Depot | • Inspection Bay Line- 2 Platforms 400m long & 3m wide.<br>• Stabling Bay Line- 7 Platforms 410 m long & 3m wide. | Industrial roof | | |

| | | | | |
|---|---|---|---|---|
| Aggregator (Feeder) stations | 2 direct access platform of 200m length and 6m width. | RC framed structure | 4 bays | |

Solar cells are planned to be kept at roof top over the steel trusses / frames.

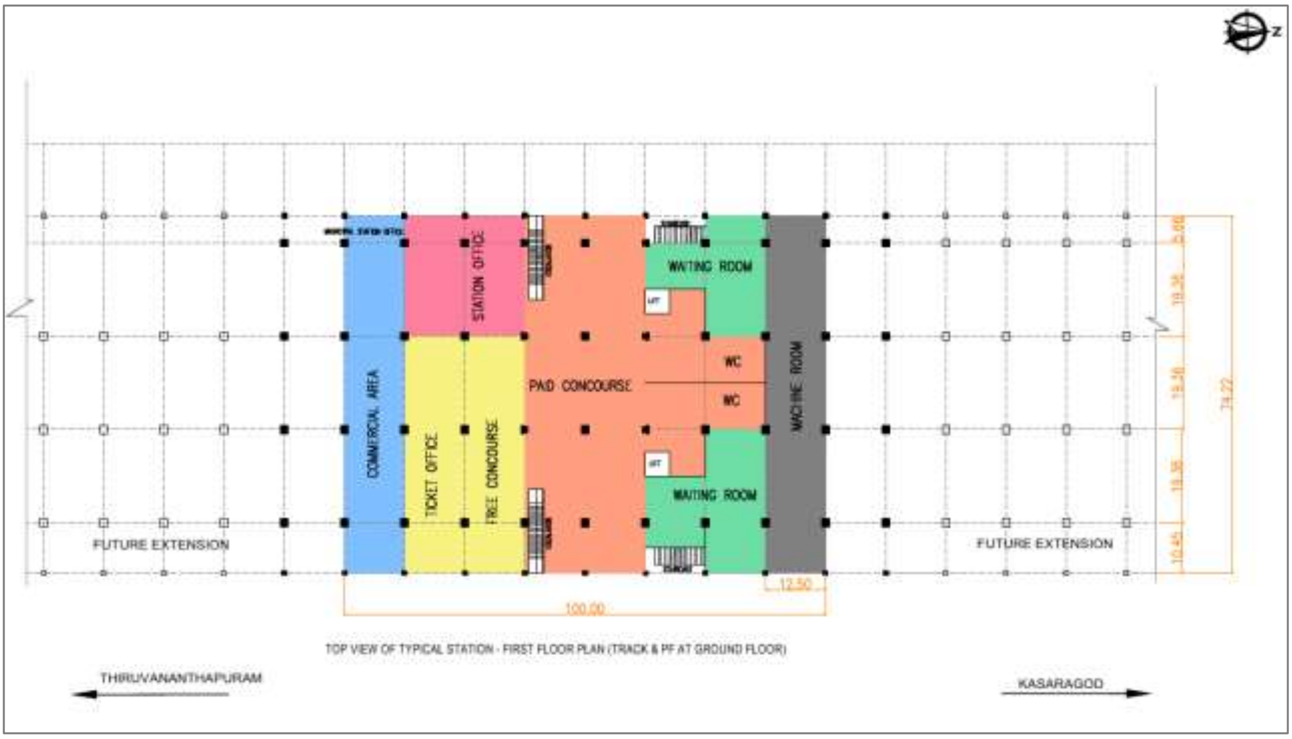



Figure 7-9: Kollam Station


Figure 7-10: Wayside Stations

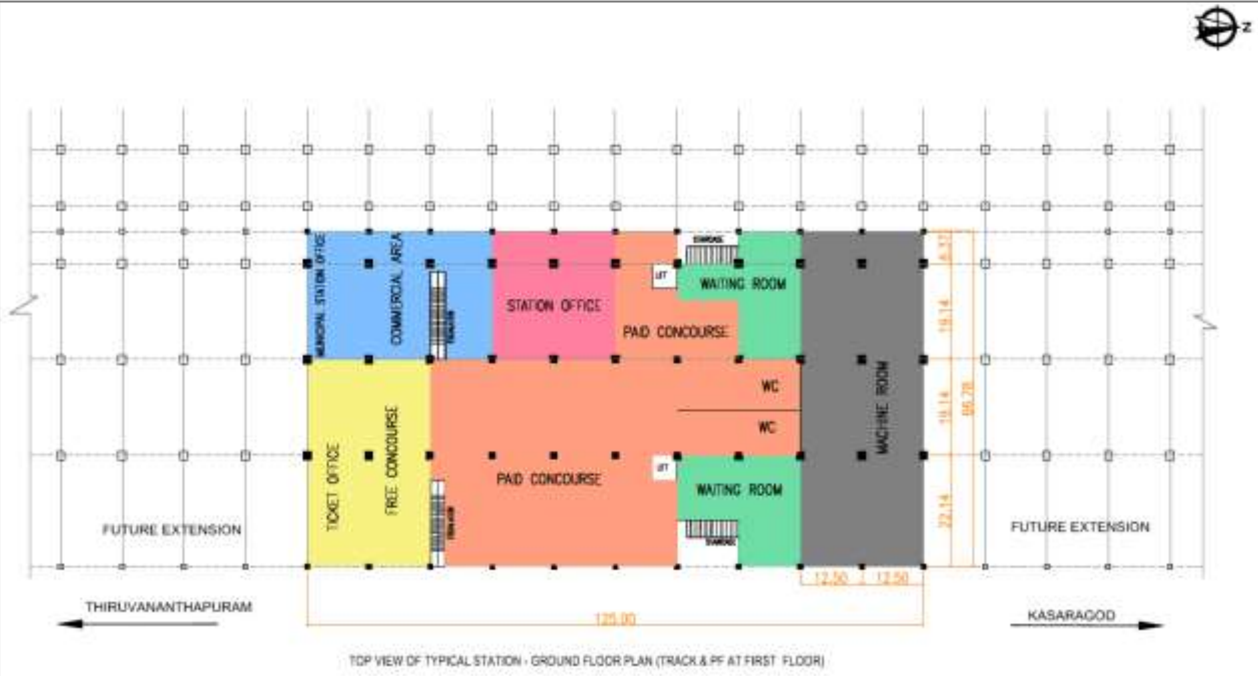



**Figure 7-11: Kozhikode Station**

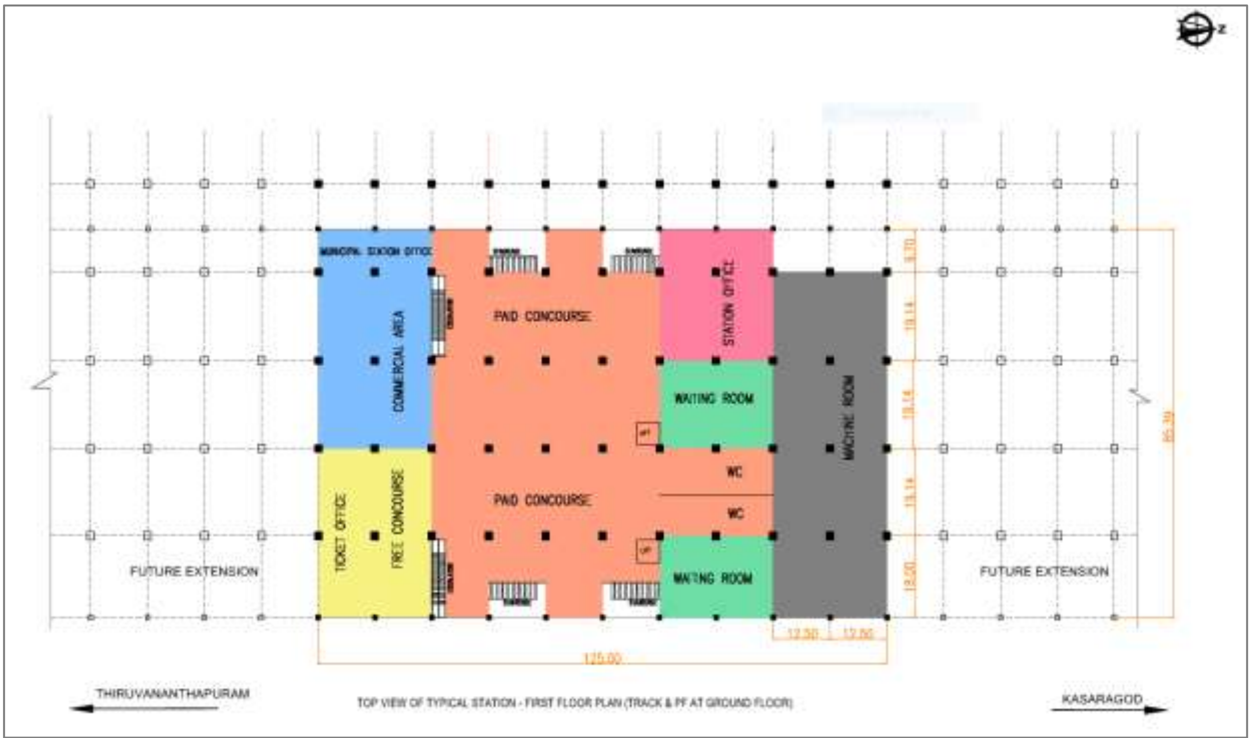



**Figure 7-12: Terminal Stations**

**Table 7-6: Silver line Station Elements Proposed**

| Station Name | Thiruvananthapuram | Kollam | Chengannur | Kottayam | Ernakulam | Thrissur | Tirur | Kozhikode | Kannur | Kasaragod |
|---|---|---|---|---|---|---|---|---|---|---|
| **Location** | 0m | 55338m | 102900m | 136108m | 195329m | 259117m | 320562m | 357868m | 446095m | 529450m |
| **Station Type** | Elevated | At Ground | At Ground | At Ground | Elevated | Elevated | At Ground | Underground | At Ground | At Ground |
| **Platform Type** | Island/Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform | Island/ Side Platform |
| **Rail Level from Ground (m)** | 4.54 | 3.43 | 2.74 | 6 | 3.12 | 11 | 2.1 | 5.3 | 3.12 | 2 |
| **Platform Length (m)** | 410/400 | 410/116 | 410/200 | 410/200/116 | 410/400 | 410/ 350/200 | 410/400/116 | 410/116 | 410/400/116 | 410 / 400 |
| **Platform width (m)** | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m | 11.32m, 8m |
| **Station Area ($m^2$)** | 22000 | 15000 | 12000 | 12000 | 24000 | 20000 | 12000 | 20000 | 15000 | 15000 |
| **Platform Floor Area ($m^2$)** | 21538.4 | 18516.72 | 12482.4 | 11810.4 | 21538.4 | 14844.4 | 13410.4 | 12451.6 | 13410.4 | 21538.4 |
| **Concourse Floor Area ($m^2$)** | 10673.75 | 9277.5 | 7947.5 | 7947.5 | 10673.75 | 7947.5 | 7947.5 | 8347.5 | 7947.5 | 10673.75 |
| **No. of Gates** | 4 | 2 | 2 | 2 | 4 | 4 | 2 | 4 | 2 | 2 |

**Table 7-6: Silver line Station Elements Proposed**

| Station Name | Thiruvananthapuram | Kollam | Chengannur | Kottayam | Ernakulam | Thrissur | Tirur | Kozhikode | Kannur | Kasaragod |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of Elevators (Paid area/ Public area) | 4 | 2 | 2 | 2 | 4 | 4 | 2 | 2 | 2 | 2 |
| No. of Escalators (Paid Area/Public Area) | 4 | 2 | 2 | 2 | 4 | 4 | 2 | 4 | 2 | 2 |
| No of Staircases (Paid Area/Public Area) | 4 | 4 | 2 | 2 | 4 | 4 | 2 | 4 | 4 | 2 |
| No of Toilets (M/F/Disable) | 4 / 4 / 1 | 2 / 2 / 1 | 2 / 2 / 1 | 2 / 2 / 1 | 4 / 4 / 1 | 4 / 4 / 1 | 2 / 2 / 1 | 4 / 4 / 1 | 2 / 2 / 1 | 2 / 2 / 1 |
| Transit to Local Railway | Yes | To connect to NH bypass | Bus (M C Road) | Bus | Kochi Metro | Southern Railway | Southern Railway | Southern Railway | Bus Depot | Southern Railway |

### 7.9.2 Signal & Communication

In the main Station, behind the commercial area the following space may be provided for signalling & train control, communication and ticketing.

#### 7.9.2.1 For Signals & Communication

**Table 7-7: Space allocation for signalling & allied activities**

| Sl. No | Name of Room | Minimum Surface area required | Remarks |
|---|---|---|---|
| 1 | Signalling & communication equipment's Room | 80 Sq. Mtrs. | At every station & depot |
| | | 40 Sq. Mtrs. | Approx. every 7-8 km on track side |
| 2 | Station/Depot Control Room | 20 Sq. Mtrs. | At every station & depot |
| 3 | Power Supply System (UPS) | 60 Sq. Mtrs | At every station |
| | | 30 Sq. Mtrs | Approx. every 7-8 km along the track side ( near to track ) |
| 4 | Radio Tower | 16 Sq. Mtrs | Approx. every 3-4 Km along the track side |
| 5. | Security Room (CCTV) | 60 Sq. Mtrs | At every station & depot |

#### 7.9.2.2 For Ticketing System

**Table 7-8: The space requirement for ticketing system at station.**

| Sl. No | Name of Room/ Space | Minimum Surface area required | Remarks |
|---|---|---|---|
| 1 | Ticket office Main Station | 80 Sq. Mtrs | At every station both side of Station / As per station Layout |
| 2 | Ticket office Aggregate Station (If required) | 40 Sq. Mtrs | At every station both side of Station / As per station Layout |

| Sl. No | Name of Room/ Space | Minimum Surface area required | Remarks |
|---|---|---|---|
| | | | |
| 3 | Automatic gates (AG), TVM | As per station layout | At every station both side/ single side as per station layout |
| 4 | Information Centre /EFO | 30 Sq. Mtrs | Near to Ticket Office at Station |
| 5 | Cash handling room / AFC Store room (for Ticketing equipment) | 30 Sq. Mtrs | Attached /Near to Ticket office at Station |

The space requirement for OCC & BCC, the area required shall be as per the final system configuration of the equipment and networking configuration with keeping space for further expansion also.

All the equipment rooms for Signalling & Communication and Ticketing system should be provided at above mentioned location with following minimum facilities:

- Air-conditioning system
- Fire protection system (as per system required)
- Earthing and Lightning protection system
- Access control (security) system (as per requirement)

## 7.10 CONCOURSE DESIGN

### 7.10.1 Hybrid Structures

Hybrid consist of a combination of RCC structures supporting the platform, station building etc., temporarily supported with a steel / Aluminum roof at the top which can be dismantled at a future for vertical expansion as needed. Over the platform heavy column are avoided to have a clear unobstructed passage for the passengers. Integrated structures with architectural elements such as transport roof, wind break screens etc. to have adequate natural lighting.

### 7.10.2 Capacity

Station patronage is a function of the station catchment area as defined in the preliminary planning process. The basis of determining the patronage at any specific station entrance shall be based on the Travel Demand Forecasting Model, or

equivalent, which establishes design passenger flows entering and exiting the station from each zone in the catchment area. The concourse area will be determined by this model, the LOS established in section 7.9.1 and incorporation of the requirements of the specific type and size of station amenities such as food shops, retail shops etc. that the K-Rail proposes to include in this space.

Calculations for the actual size of a concourse will involve at a minimum the establishment of a peak passenger load for the concourse developed by the model (which may vary from the peak departure load depending on the station operation) times the LOS criteria minus the area to be occupied by amenities and the requisite space factors applied for circulation and access.

### 7.10.3 Design

The design of the concourse and station control areas shall channel and segregate incoming and outgoing passengers to minimize crossflows and conflicts. Arrival and departure areas should be distinct and separate and where feasible on different levels with no direct passenger connection between them. Arrival areas should be in the direct flow of passenger traffic entering the station and platforms. Departure areas should be remote from arrival areas and facilitate exiting through different station access point from the main arrival areas. Concourse area will be contiguous with all main entry gates and contain the following functions;

(i) Access to all platforms
(ii) Unreserved waiting areas
(iii) Reserved waiting areas
(iv) Lounges
(v) Toilets
(vi) Cloak room (luggage storage)
(vii) Concessions (food shops, convenience retail shops)
(viii) MOR managed food shops (unreserved waiting areas)
(ix) SIC’s
(x) TVM’s
(xi) IIC’s
(xii) ATM’s
(xiii) Public Security stations

Concourse will be the main congregation space for the station. Its design should reflect the highest quality public space aesthetic for public open space. The finishing materials should be of the highest durability and be of appropriate acoustic qualities.

The amenities contained therein should be arranged to facilitate the efficient and comfortable movement of passengers through the space and accommodate the amenities noted above in an orderly and visually pleasing manner. The space should be organized so as the facilitate wayfinding from the entrance to the paid concourse area to the departure platforms requiring a minimal amount of signage.

The environmental systems should maintain the main departure Concourse space at a maximum temperature of 29$^{o}$ C and should maximize the amount of natural light and ventilation. All other enclosed passenger spaces on concourse besides toilets shall be air-conditioned according to NBC standards.

### 7.10.4 VCEs (Vertical Circulation Elements)

VCEs are the devices used to transport customers between different levels of the station. VCEs comprise of elevators, escalators, and stairs (including emergency egress stairs). Capacity requirements for VCE's will be determined on a component by component basis. The most critical will be the platform which is the basic unit of operation in the train station. VCE requirements for a typical platform will be highlighted in a sample calculation in section 7.11.4.1. General planning principles for each type of VCE follow.

(i) Provide Escalator/Stair Pairs - Wherever feasible, stairs and escalators shall be provided side-by-side to facilitate a choice in vertical travel.
(ii) Provide Elevators in Pairs – Unless infeasible on existing platform areas elevators shall be installed in pairs side by side wherever they are used for public access.
(iii) Provide Adequate Capacity (Minimum Number of VCEs) -The minimum number of VCEs will be determined by the level of service, given the forecast peak passenger design loads or emergency egress requirements, whichever is most stringent. However, a single upward escalator and stair pair will be considered as the minimum vertical circulation unit at any point of vertical circulation.

#### 7.10.4.1 Escalators

Where possible, the escalators shall be evenly distributed along the whole length of the station so as to avoid a concentration of passengers at a particular area. An escalator working point shall preferably be not less than 9 m from any obstruction across the direct path of passengers. Where escalators are arranged in banks, the clear distance from the escalator working point shall be increased by at least 1 m for each additional escalator. Traffic flow across the path of passengers is deemed as an obstruction.

Where escalator(s) are provided in the lower portion, the landing between the upper and lower portions shall not be less than 5.5 m free length from the escalator working points. If the entrance is angled there shall be not less than 4 m straight from the working point, but if there is a choice of direction not less than 5.5 m.

Features shall include:

(i) A smoke containment bulkhead shall be provided at the foot of all stairs and escalators serving the platform level. It shall extend to the structural soffit from a height of 3 m above the platform finished floor level.

(ii) The minimum distance between working points of escalators working in opposing directions is 17 m.

(iii) Where possible, passengers shall not have to travel from one passenger level to the next by more than one escalator. However, all escalators and staircases provided for interchange passenger flows from a level below ground to a level above ground shall preferably have a break at ground level for emergency evacuation facility.

(iv) All escalators shall be of the heavy-duty reversible type with a design maximum practical capacity of 90 persons per minute based on a service speed of 0.65 m/sec. The following requirements are given for general planning purposes:

a. Inclination 30 degrees
b. Step speed 0.65 m/s
c. Step width (min) 1000 mm
d. Number of flat steps at upper landing 4 (min)
e. Number of flat steps at lower landing 4 (min).

**Applications**

(i) Application
   a. Provide an escalator where the vertical path of travel exceeds 3.658 m.
   b. At least one path of vertical egress assisted by an escalator shall be available from any point in the station in both directions.
   c. Level of Service -The following performance standards will be used for station planning.
   d. 1219 mm nominal (two-lane) escalator.
   e. Capacity: Approximately 90 persons per minute. (see 4.5.4.5 for capacity for calculation emergency egress)
   f. Queuing areas: LOS C.

(ii) Location
   a. Escalators shall be located along the normal and direct path of passenger circulation and be visible and easily identifiable as a means of access to the levels they connect.
   b. Where feasible, escalators shall be paired with stairs, to facilitate efficient and economical passenger movement.

(iii) Queuing and Runoff Space
   a. Provide a minimum of 9.146m of queuing and runoff space, as measured from the upper and lower escalator working points, clear to any obstruction at the top and bottom of each escalator.
   b. Where escalators are located in sequence between levels and there are no pedestrian cross-flows or other obstructions to customer movement (e.g., at intermediate landings independent of intervening customer circulation elements), the required combined queuing and runoff space may be reduced by 25%.

(iv) The width of the queuing and runoff space shall correspond to the modular width of the escalator.

(v) Street level condition, working point to curb 13.719 m minimum.

#### 7.10.4.2 Elevators/Lifts

The criterion for locating elevators is as follow:

(i) Accessibility: Elevators shall be conveniently located for all passengers and facilitate access for the mobility impaired and the disabled.
(ii) Catchment area: Elevators to street level shall be located to serve the broadest possible portion of the station's catchment area.
(iii) Inter-modal transfer: Elevators shall be located to provide convenient access to bus stops and other modes of public transportation.
(iv) Elevators shall be located as closely as possible to other VCEs (stairs and escalators) in the station.
(v) Visibility: Elevators should be located to provide service along the normal path of passenger travel and positioned to be easily identifiable to passengers with a minimum of signs. Elevators shall be visible to security personnel, station staff, and the general public for security and surveillance purposes. Shafts and cabs shall be transparent for maximum visibility of the cab interior. Closed-circuit television (CCTV) surveillance shall be provided within the cabs and at all waiting areas.
(vi) Elevators shall be located in a consistent manner on the platform from station to station to facilitate customer wayfinding and orientation. In general, elevators should be centered along the length of the platform adjacent to the middle car(s) of the train.
(vii) Elevators shall be located so as not to obstruct general passenger circulation or visually obscure other VCEs along the path from concourse area to platform.

#### 7.10.4.3 Ramps

Ramps shall only be used for small changes in level or for use by wheelchairs and the following gradients shall apply:

(i) preferred gradient 1:20
(ii) maximum gradient 1:12

Ramps shall be a minimum width of 1200mm for unidirectional movement and 1500mm for bi-directional movement. Rest platforms should be considered for long ramps (exceeding 10m) provided for wheelchair users. Rest platforms should provide a level area 1800mm long at intervals of approximately10m.

Capacity of ramp as defined in NFPA 130 as .0819 per millimeter per person per minute. Minimum size of ramp is .914m.

#### 7.10.4.4 Stairs

Public stairs are intended for normal passenger circulation. Because of the safety hazards and energy expenditure associated with human locomotion on a stairway, designers must be particularly cognizant of the passenger behavior and traffic patterns of railway stations.

**a) Application**

(i) Stairs are the primary mode of vertical circulation for meeting emergency egress requirements (e.g., NFPA 130).

(ii) Stairs shall be used as the primary mode of vertical circulation where the vertical rise between levels is less than 2.439 m

(iii) Stairs are recommended as the primary mode of vertical circulation for the downward movement of customers where the vertical rise between levels is less than 6.097 m.

(iv) Stairs should not be provided as a means of normal public access (as distinguished from emergency egress) where the vertical rise between levels exceeds 10.975 m.

**b) Location**

(i) Stairs shall be located along the normal and direct path of passenger circulation and be visible and easily identifiable as means of access to the levels they connect.

(ii) Wherever feasible, stairs shall be paired with escalators to facilitate efficient and economical passenger movement.

**c) Width**

(i) Wherever practicable, all stairs shall be planned using modular width corresponding to the applicable escalator module used in the station design (including installation and construction tolerances), and designed to facilitate replacement by an escalator in the future.

(ii) Where use of an escalator width as a modular dimension is not possible or appropriate, the minimum width of a stair shall be 1.524 m or as determined by passenger demand based on LOS, service standard, or emergency egress requirements.

#### 7.10.4.5 Travellators

Where there are substantial distances to be traversed within stations and /or between stations and intermodal connections the use of a travellators (people mover) may be considered. Design considerations when their use is proposed include:

(i) Parallel walkways to travellator.

(ii) direction of travel should be shown clearly and the footway at both ends should be marked by color contrast and a change in floor finish.

(iii) The travellator must be well lit, particularly at its entrance and exit.

(iv) Moving handrails should be rounded in section, in a color which contrasts with the background and should extend approximately 700mm beyond the beginning of the walkway.
(v) The recommended width is 1500mm.
(vi) Side panels should be finished in a non-reflective surface.
(vii) The recommended speed of movement of the travellator is 0.5m/second (0.75m/second maximum).
(viii) The surface should be non-slip and there should be clearly visible emergency stop switches that can be reached and operated by disabled people.
(ix) An audible warning at the beginning and prior to the end of the travellator
(x) Should have a minimum unobstructed level run-off at each end of 6 m.
(xi) The maximum gradient should be 5 per cent (1 in 20) Reference Department of Transport –Inclusive Mobility (UK)

#### 7.10.4.6 Modular Planning and Interchangeability

Escalators and stairs shall be sized in modular units of width, based on the width of the escalator planned for use in the station in order to permit the future replacement of stairs with escalators (or escalators with stairs) as dictated by passenger demand. The planning module shall include provisions for external escalator drives if applicable. Structural, mechanical, and spatial provisions shall be made during design to accommodate the future interchangeability of stairs and escalators in the original construction.

## 7.11 STATION SQUARE

Station Square is a common area being made use by passenger and visitors.

Area for station square is proposed based on formula and to be in the range of

$$A = 40 \text{ to } 50 \sqrt{P}.$$

Subject to minimum of 3500 $m^2$ (P is total number of passengers and visitors in a day)

**Table 7-9: Proposed Areas of Station Square**

| Sl. No. | Proposed Area | No. of Users (P) / Day | Area (Sq. m) | Adopted Area (Sq. m) |
|---|---|---|---|---|
| 1 | Thiruvananthapuram | 75,498 | 13738 | 13738 |
| 2 | Kollam | 23,403 | 7649 | 7649 |
| 3 | Chengannur | 14,099 | 5937 | 5937 |
| 4 | Kottayam | 24,024 | 7750 | 7750 |
| 5 | Ernakulam | 67,413 | 12982 | 12982 |
| 6 | Kochi Airport | 14,536 | 6028 | 6028 |

| Sl. No. | Proposed Area | No. of Users (P) / Day | Area (Sq. m) | Adopted Area (Sq. m) |
|---|---|---|---|---|
| 7 | Thrissur | 32,419 | 9003 | 9003 |
| 8 | Tirur | 9,798 | 4949 | 4949 |
| 9 | Kozhikode | 41,550 | 10192 | 10192 |
| 10 | Kannur | 39,514 | 9939 | 9939 |
| 11 | Kasaragod | 16,997 | 6519 | 6519 |
| | **Total** | **359,249** | **94686** | **94686** |

## 7.12 PARKING SPACE

Area required = 25 $m^2$ per car * ABC/2

C = 1.3 per car

B = % of private car

A = Number coming in and going out

From the above, B is observed to be 23% based on the passenger terminal O-D surveys and analysis.

**Table 7-10: Estimated space for parking**

| Sl. No. | Proposed Area | No. of Users (P) | Person Trips by Car | Total Cars coming in and out (Daily in No.s) | Area of Parking (in Sq.M)# |
|---|---|---|---|---|---|
| 1 | Thiruvananthapuram | 34,150 | 7855 | 3460 | 71590 |
| 2 | Kollam | 10,250 | 2358 | 1039 | 6456 |
| 3 | Chengannur | 6,160 | 1417 | 624 | 2328 |
| 4 | Kottayam | 10,390 | 2390 | 1053 | 6631 |
| 5 | Ernakulam | 29,420 | 6767 | 2981 | 53140 |
| 6 | Kochi Airport | 6,340 | 1458 | 642 | 2465 |
| 7 | Thrissur | 13,790 | 3172 | 1397 | 11671 |
| 8 | Tirur | 4,320 | 994 | 438 | 1147 |
| 9 | Kozhikode | 17,630 | 4055 | 1786 | 19075 |
| 10 | Kannur | 16,660 | 3832 | 1688 | 17039 |
| 11 | Kasargod | 7,080 | 1628 | 717 | 3074 |
| | **Total** | **156,190** | | | |

*# the estimated area is tentative and is an overall built-up area required for accommodating the car parking spaces. In later phases, based on parking survey estimates, multi-level car parking (MLCPs) shall be proposed.*

## 7.13 LOUNGES & WAITING AREA

### 7.13.1 Capacity

Capacity of waiting areas shall be based on the station capacity analysis model that must include a passenger profile to establish the waiting area requirements for reserved and unreserved passengers as well as the premium lounges. Following is a sample calculation for the different types of concourse waiting spaces.

**Table 7-11: Sample Calculation for Concourse Waiting Space**

| Waiting Area | Total peak | LOS | $m^2/p$ | Total Area $m^2$ |
|---|---|---|---|---|
| Unreserved | 1,750 | C | 1.80 | 3,150 |
| Reserved | 560 | B | 2.25 | 1,260 |
| 1st class lounge | 250 | A | 2.61 | 653 |
| Executive lounge | 50 | A+ | 3.00 | 150 |
| **Total waiting area** | | | | **5,213** |

*Source: IATA standards for waiting areas*

### 7.13.2 Types of Waiting Areas

**Figure 7-13: Image of Waiting Room for Second Class Passengers**

Size and location of the lounges and waiting areas may be decided taking into account the climatic conditions, the importance of the stations, availability of space, etc. Premium lounges with special amenities shall keep in view the demand from different type of clientele. Types of areas are:

(i) Unreserved waiting areas, amenities include:

a. Seating
b. Toilets
c. K-Rail food shops
d. K-Rail food and retail shops
e. Drinking Water facility

(ii) Reserved waiting areas, amenities include.

a. Seating
b. Toilets
c. Food and retail shops (restaurants)
d. Cyber cafes
e. Cell and computer charging points
f. Wi-Fi
g. Drinking Water facility

(iii) Premium lounge amenities include

a. Upholstered seating
b. Separate climate control.
c. Toilets and showers
d. Food and retail shops (restaurants)
e. Cyber cafes
f. Cell and computer charging points
g. Wi-Fi
h. Drinking Water facility
i. Entertainment Systems

There are option of deciding various levels of lounges that may use to earn revenue at the station's unpaid zone. These may be in form of short- or long-term lounges with amenities starting from minimum requirements to luxury levels.

**Figure 7-14: Image of Lavatories for Silver line**

### 7.13.3 Design Requirement

(i) K-Rail will survey and analyse the data for the specific requirement for lounges in terms of numbers and levels of luxury.

(ii) Adequate toilet facilities will be provided based on number of passengers using the facilities. The K-Rail will assess, evaluate and decide the number and size of premium lounges.

(iii) Adequate numbers of toilet to maintain clean and hygienic situation at all times.

### 7.13.4 Maintenance

(i) All lounges and waiting rooms shall be maintained by the K-Rail /its SPV/Private company.

(ii) All rest rooms and other amenities including any food service areas connected to lounges must be maintained in accordance with national health and safety requirements and local municipal corporations' regulations, whichever is more stringent.

## 7.14 PARKING AND VEHICULAR CIRCULATION

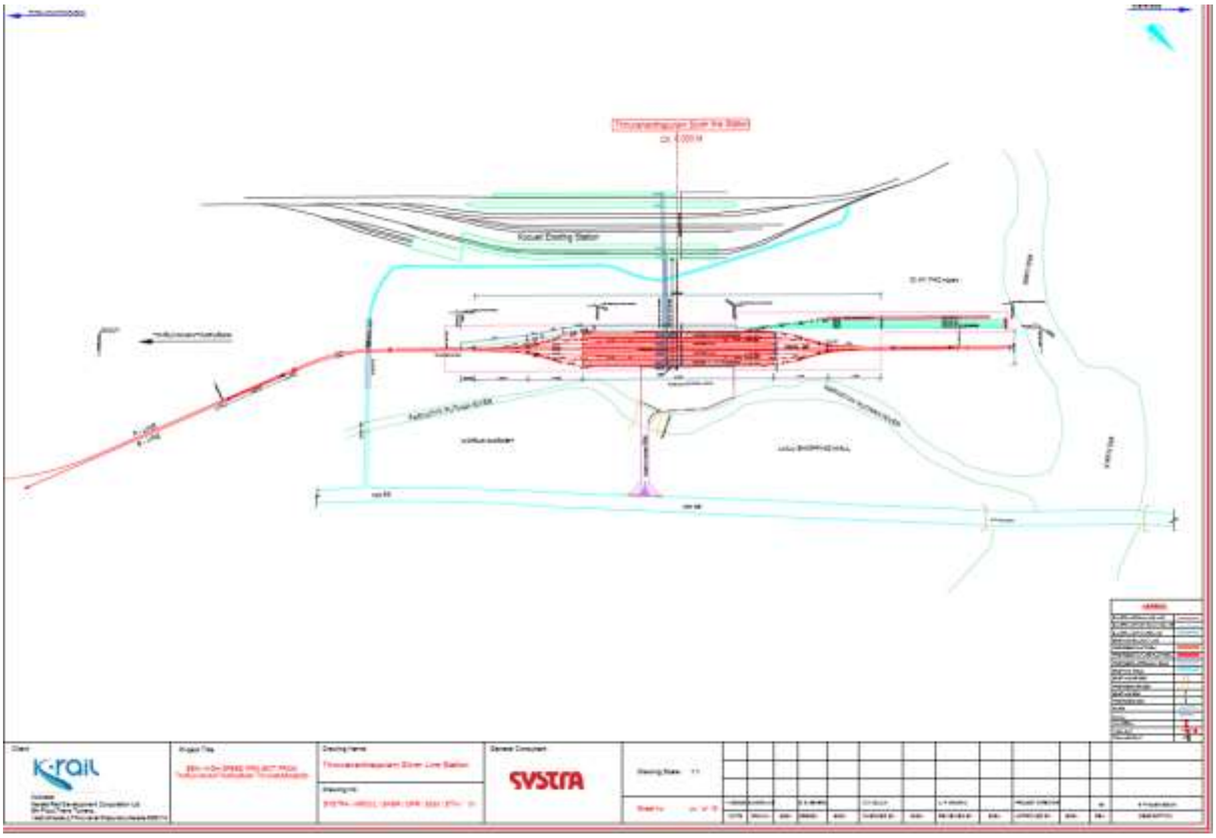


**Figure 7-15: Thiruvananthapuram SilverLine Station Layout Plan**

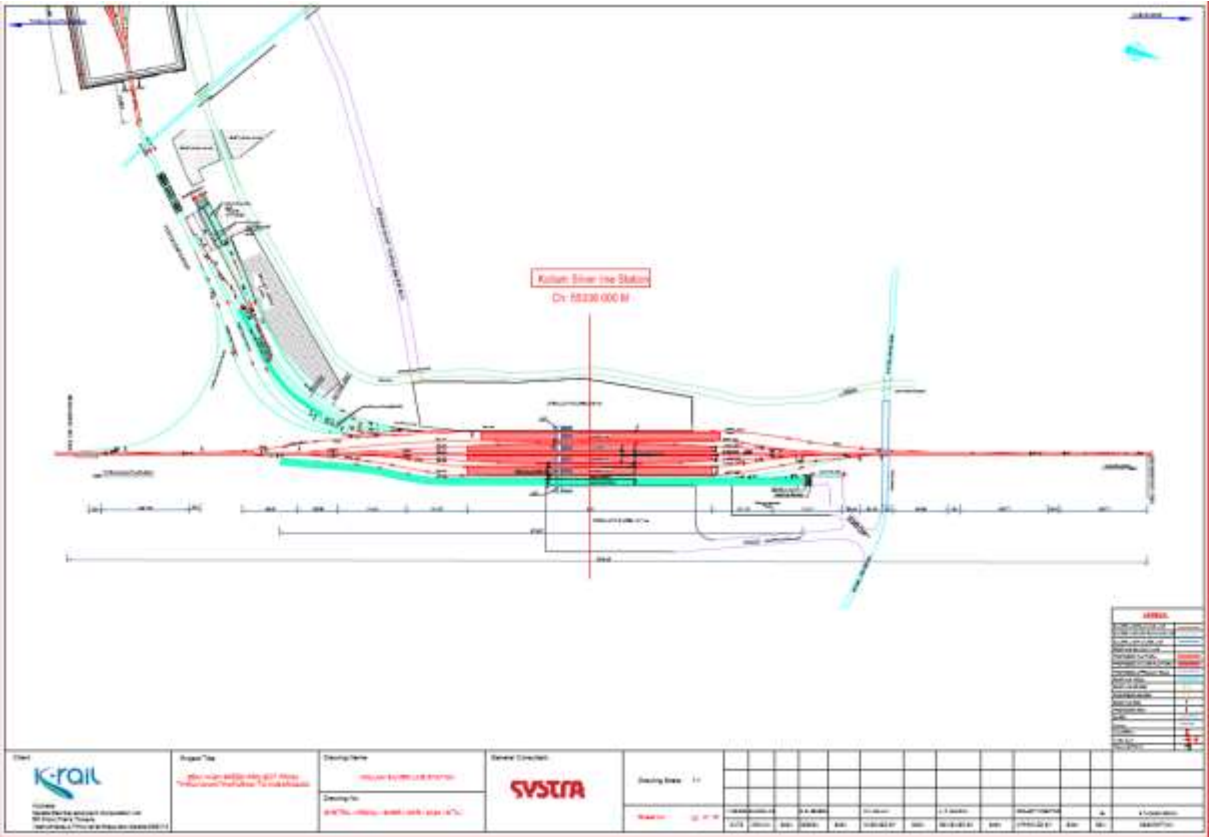



**Figure 7-16: Kollam SilverLine Station Layout Plan**

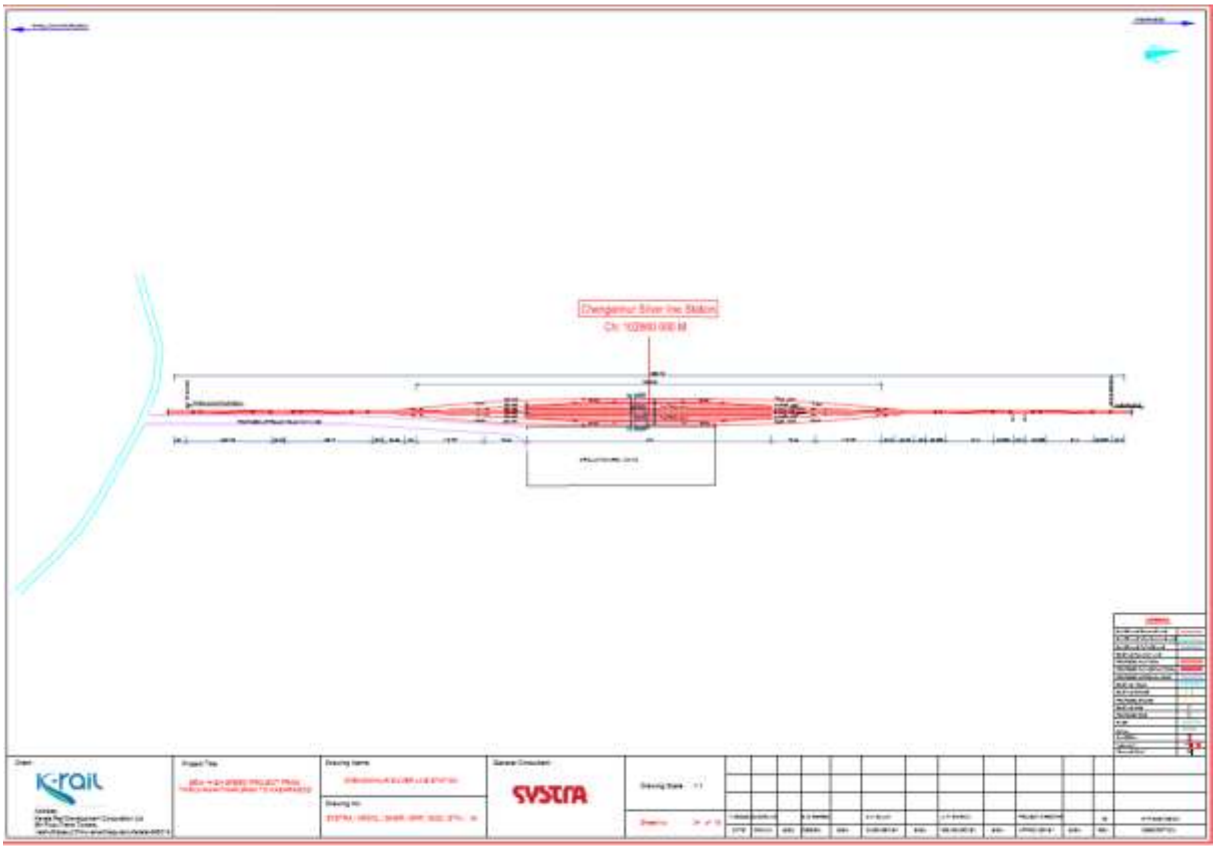



**Figure 7-17: Chengannur SilverLine Station Layout Plan**

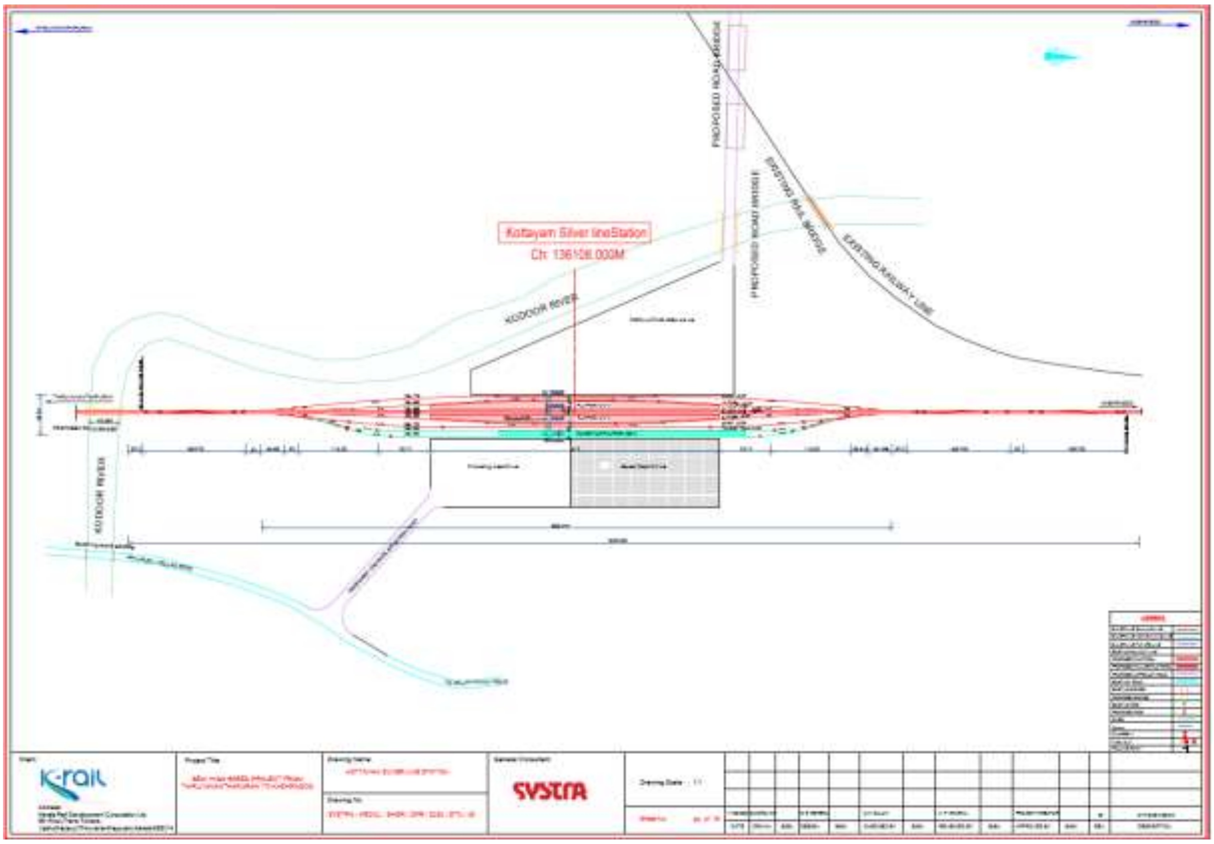



Figure 7-18: Kottayam SilverLine Station Layout Plan

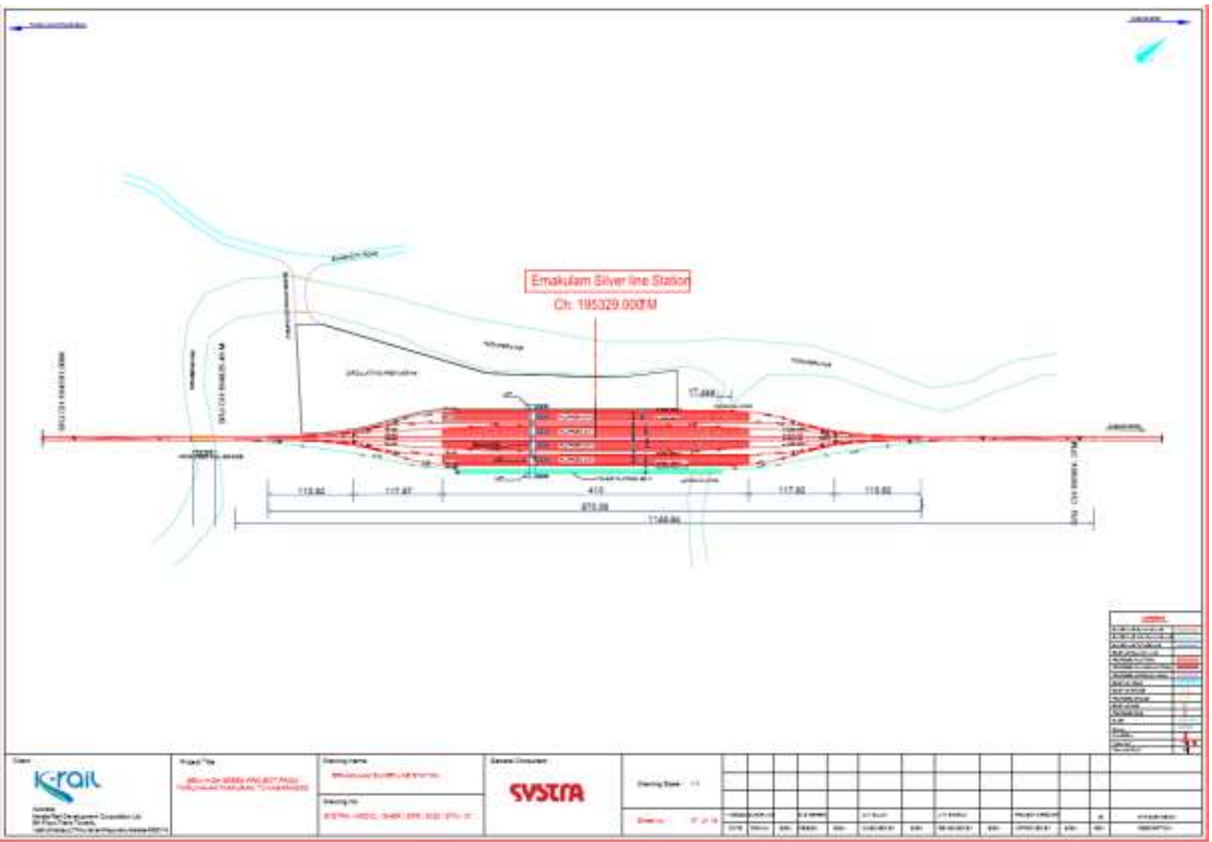



Figure 7-19: Ernakulam SilverLine Station Layout Plan

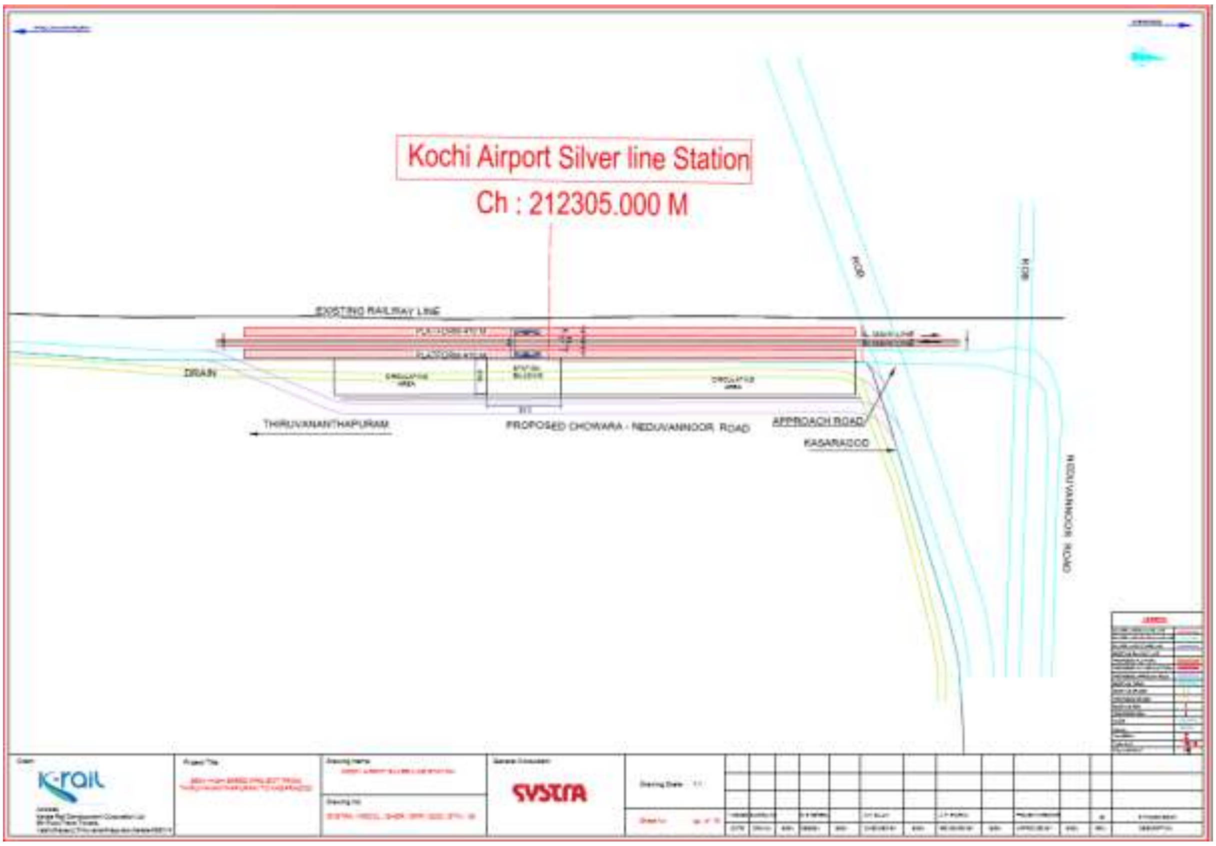



Figure 7-20: Kochi Airport SilverLine Station Layout Plan

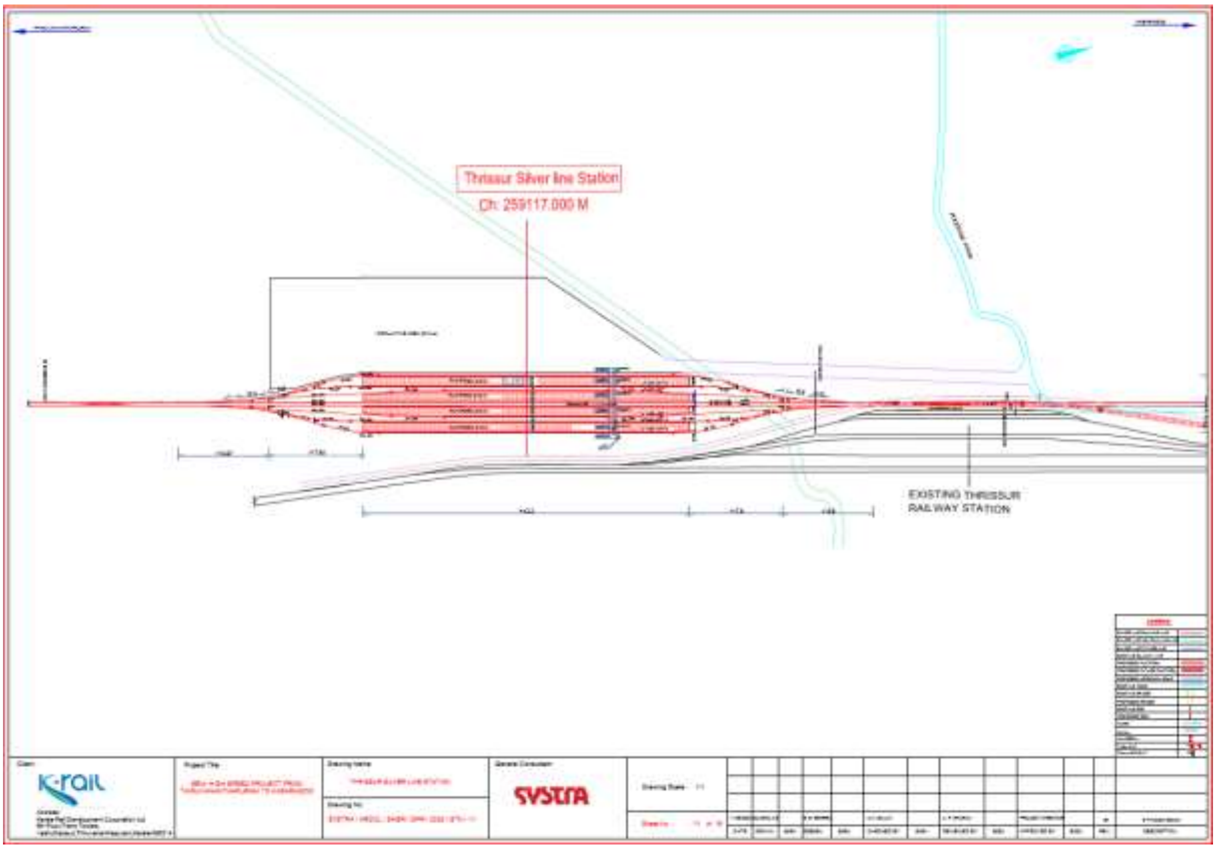



Figure 7-21: Thrissur SilverLine Station Layout Plan

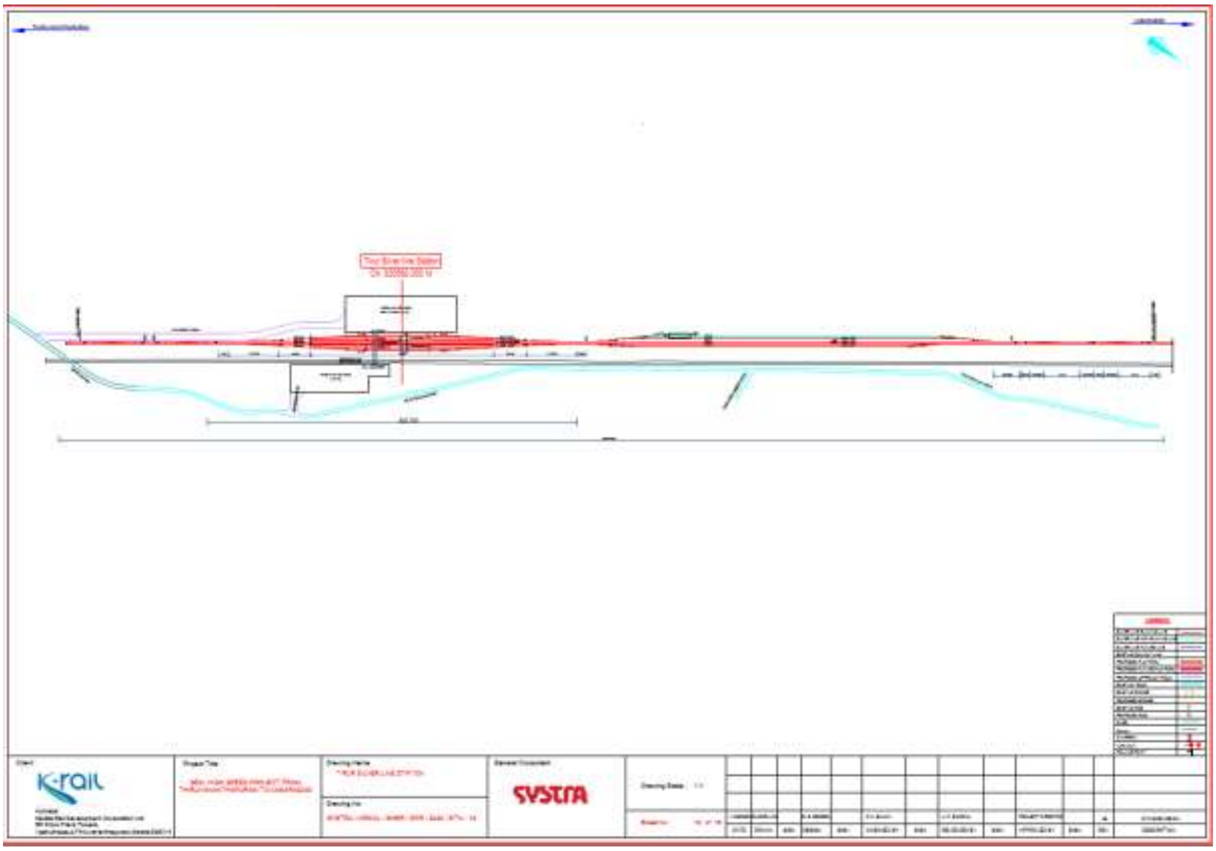


Figure 7-22: Tirur SilverLine Station Layout Plan

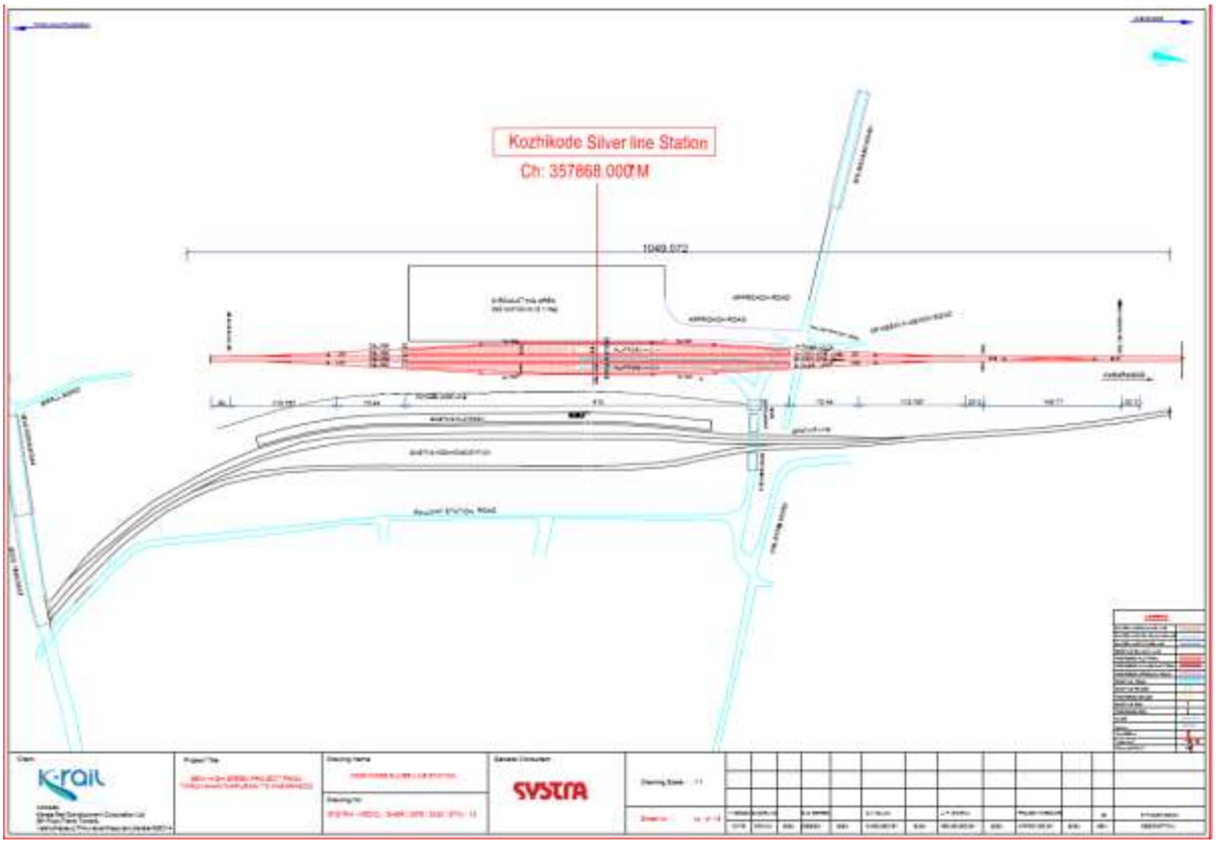



Figure 7-23: Kozhikode SilverLine Station Layout Plan

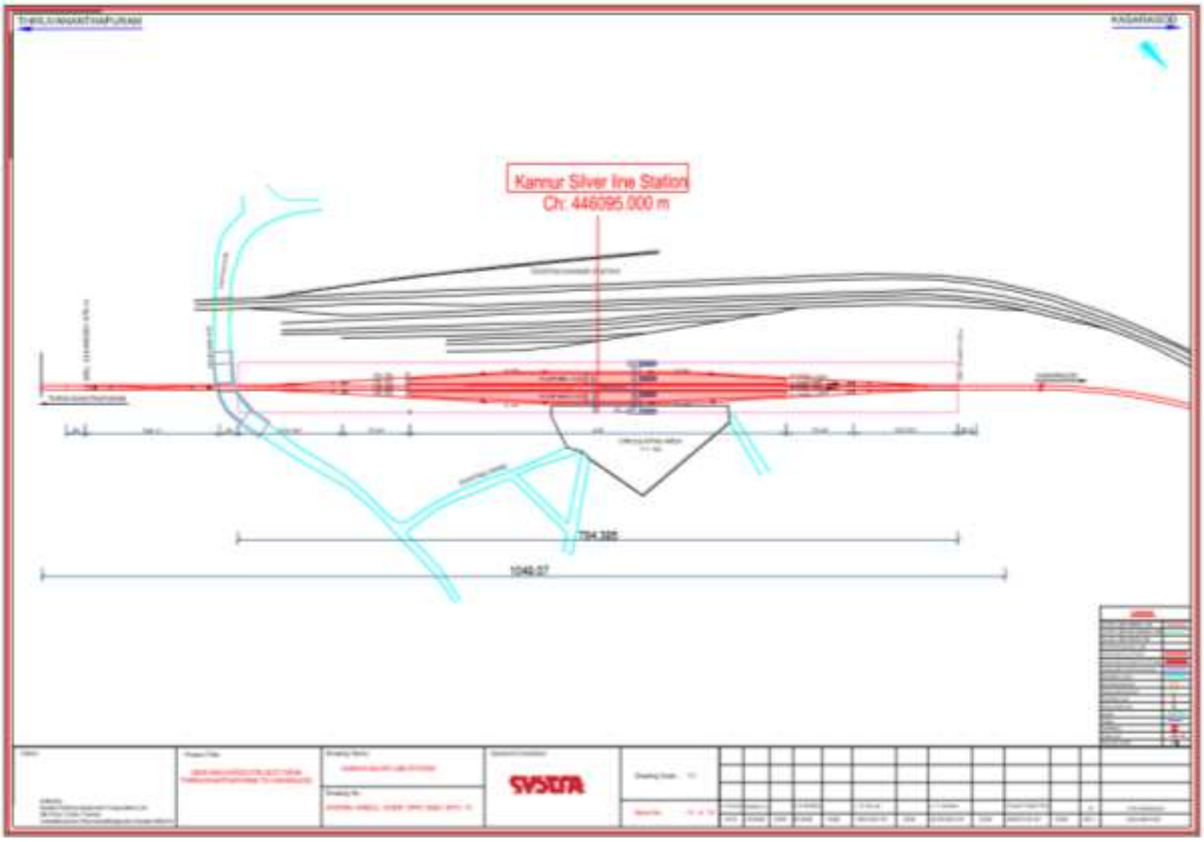



Figure 7-24: Kannur SilverLine Station Layout Plan

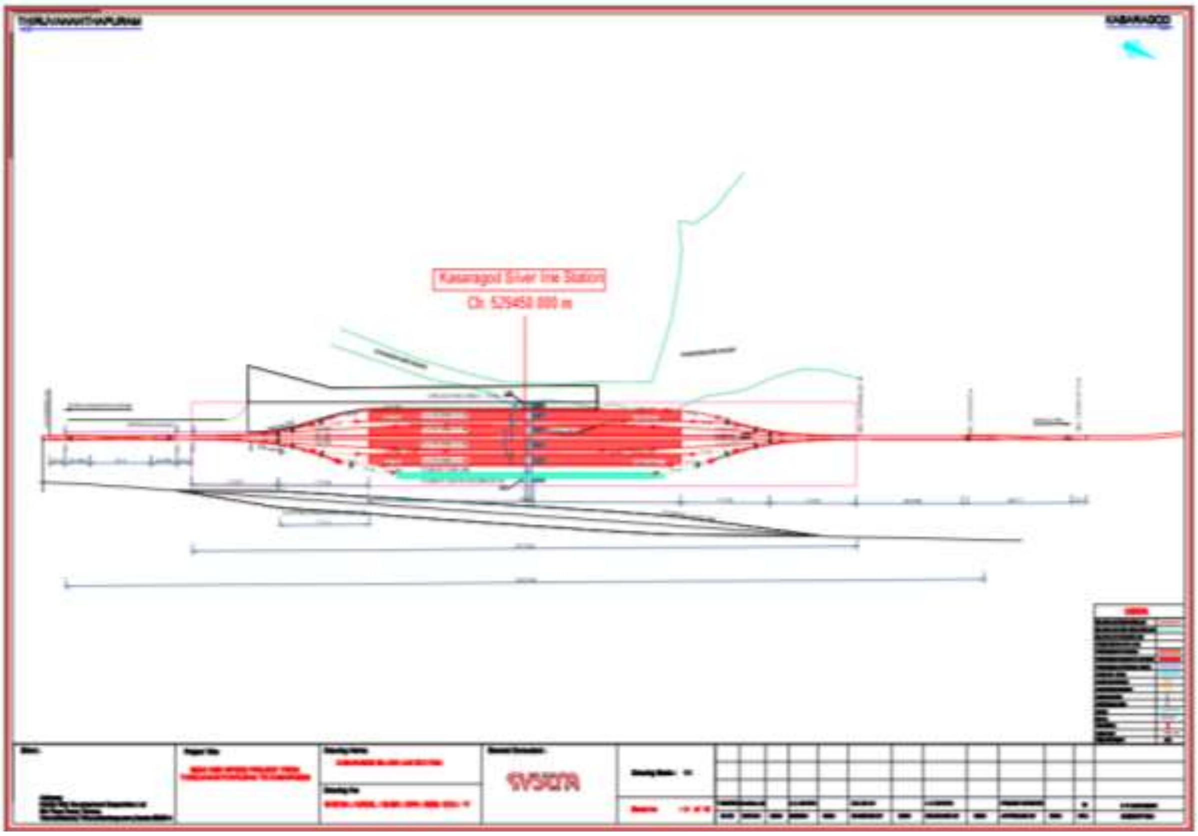



Figure 7-25: Kasaragod SilverLine Station Layout Plan

### 7.14.1 Capacity Considerations

Traffic circulation and parking service applies to all areas of the site and should ensure a free flow of traffic at all times of the day and throughout the year. Design year and design passenger load shall be established by K-Rail for each station. Other station area capacities shall be designed based on the development codes of the local jurisdiction. The capacities shall be designed for the peak hours of the day of the maximum seasonal peak of the design year.

A baseline traffic assessment study shall be done to assess the needs and project requirements for the horizon design year. The provision of parking bays shall depend on average parking demand and turnover time and Level of Service C as per table 7-1 shall be considered for future requirements. Parking accumulation survey, parking duration survey and classified traffic volume surveys at entry / exits shall be done on peak days of the week for duration of 24 hours to determine parking demand in the present condition, modal distribution of this demand in vehicle categories such as private cars, two wheelers, buses and other category of vehicles.

Proposed parking shall have minimum provision of parking bays as per the baseline studies and maintaining Level of Service C. However, the provision of parking for peak demand shall be as follows based on established peak parking demand.

**Table 7-12: Parking Provisions (For Peak Demand)**

| Sl.No. | Vehicle Category | Mandatory Parking Provision |
|---|---|---|
| 1. | Personalized Cars | Minimum 60 % |
| 2. | Personalized Two Wheelers | Minimum 75 % |
| 3. | Taxies | Minimum 50 % |
| 4. | Auto rickshaws & other IPT | Minimum 50 % |
| 5. | Cycles | Minimum 80 % |
| 6. | Public Transport | Minimum 80 % |
| 7. | Other modes | Minimum 50 % |

The base traffic shall be forecasted for future years. The forecasts shall be inclusive of the generating / dissipating traffic due to real estate development at the station as well as in the vicinity. The radius of the circle of influence shall not be less than five kilometers for the determination of developmental traffic. K-RAIL proposes to have

gradual shift in modal split from private vehicles to hired vehicles like autos and taxis and public transport system for arrival and departure passengers at the terminals.

There shall be provision of dedicated lanes (minimum width 3.5 m) for station bound traffic for the approach roads during peak hours as determined by the station vehicle count surveys. If the traffic volume is not sufficient to justify the construction of a separate lane, the K-Rail shall work with local planning authority to cordon off the existing lanes for station traffic. This model shall be applicable for both incoming and outgoing traffic.

### 7.14.2 Design Considerations:

The location and type of parking i.e. surface parking, underground parking or multi-level parking shall be flexible and based on the above capacity requirements. Average time taken to find parking space and depart from parking space should be less than five minutes. All competing modes including private cars, private two wheelers, auto rickshaws, taxies, public transport buses / minibuses shall have provisions for proper parking facilities within the station complex. All circulation roads shall be free of on street parking.

The general layout characteristics of parking facilities will often be unique to the specific location for which they are being designed. However, certain key concepts are paramount when developing a design to provide the maximum utility to its intended users:

(i) Competing modes of access should be separated whenever possible, providing separate space for intermediate public transport (IPT) access, private vehicle access, carpool formation, bicycle access and storage, pedestrian flow, and drop-and-ride activities.
(ii) Needs for physically challenged people, Pedestrian and other modes should be elevated to be the primary design consideration in the layout and design of the facility. Handicapped Parking shall be clearly marked and situated in accordance with Indian Railways guidelines on “Passenger Amenities for Passengers/Persons with Disabilities”.
(iii) Individual access and service modes should be organized within the parking facility to minimize conflicts and maximize the efficiency of the various operations.
(iv) Provide separate access driveways for various modes and by providing separate access for short term drop-and-ride activities which includes taxis, autos and tourist buses.
(v) Clear visibility from the major access points so that drivers can quickly identify if the parking bay is full or if space is available.
(vi) Messaging system should be considered as an aid to the driver.
(vii) Provide a single continuous path for the commuter from the road to a parking space and to the railway platform with a minimum of conflicting barriers.

Maintaining this goal throughout the design process will provide a convenient and efficient parking facility.

(viii) Pedestrian access between the parking lot and the primary service mode should provide for convenient access with minimal walking distances (less than 200 meters is preferred).

(ix) Parking meters and Intelligent Parking Assist System (IPAS) shall be developed and deployed in the parking lots.

### 7.14.3 Pedestrian Requirements

Pedestrian paths within the parking lot should have the following features

(i) Clearly distinguishable throughout the facility.
(ii) Minimization of Conflicts between pedestrians and vehicles.
(iii) Raised pedestrian paths and sidewalks are preferable to parking aisles
(iv) Curb spaces immediately adjacent to the loading areas should be free of all barriers.
(v) Signage and street furniture, as well as other passenger amenities, should not interfere with loading, patron queuing, or pedestrian access.
(vi) Spaces should be provided with wheelchair ramps and curb cuts, textured pavement surfaces, and a barrier-free path between handicap parking spaces and the railway terminal.
(vii) Adequate space for full deployment and loading of vehicle lifts should be provided adjacent to each parking bay
(viii) Additional amenities such as Braille signage and audible signals should be considered as aids to visually impaired patrons.

### 7.14.4 Vehicular Circulation:

Vehicle circulation strategy within the parking facility shall be based on following features,

(i) Internal Circulation with the parking facility to be based on clockwise movement.
(ii) Encourage inbound access movement, bringing inbound vehicles on-site quickly and conveniently to prevent on-street backups at key entrances.
(iii) Facilitate easier access in the peak periods and reduce on-street congestion. Entrances should allow the accessing driver to drive past as much of the lot as possible before entering, thus allowing visual inspection of the facility for available spaces.
(iv) Access / Egress and circulation routes shall be free from vehicular and other obstructions maintaining free flow of traffic at all times.
(v) All competing modes including private cars, private two wheelers, auto rickshaws, taxies, public transport buses / mini buses shall have provisions for proper circulation, drop off / pick up facilities and parking facilities within the station complex.

(vi) All circulations in station area shall be unidirectional and preferably in clockwise direction. Arrivals and departures shall be planned such that there is no conflict of traffic.

(vii) Drop off and pick up bays shall be provided at most convenient locations. All circulation roads shall be free of On-street parking.

## 7.15 LIGHTING

### 7.15.1 Introduction

Lighting is an integral part of station architecture and as such should respond to the given architectural conditions and be coordinated with other elements of the stations. In addition to providing illumination and a sense of security, the lighting system in railway stations should be durable, energy efficient and easily maintained. The lighting in office rooms, passages, stairs, open areas etc. shall be provided as per established norms and appropriately positioned. The station designer shall prepare an analysis as called for in section 4.7.4.2 of World Class Station Manual, that demonstrates how the standards, goal and objectives for the lighting of the stations called for in this manual are met by the design.

The scope for station lighting includes, but is not limited to, lighting equipment, illumination levels, and control systems for the station in the following areas:

(i) Station Site
(ii) Platform
(iii) Station Building
(iv) Concourse
  a. Circulation
  b. Waiting
  c. Interactive Areas
  d. Service Areas.

### 7.15.2 Increase Natural Light

Wherever feasible the use of daylight is recommended. When utilized in conjunction with responsive control technology, natural light may provide sufficient illumination to warrant de-energization of designated electrical lighting, offering potential energy savings. As a side benefit, natural light can increase customers' positive sense of station orientation and identification.

Supplementing artificial lighting with natural daylight can be achieved with use of glass and through openings in the structure, directly focusing the light from open areas to remote areas, and through fiber optic lighting that uses daylight directly. Design shall demonstrate the percentage savings resulting from the use of natural light to supplement artificial light in different areas of the station during the light hours separately for different times during the day.

## 7.16 ACOUSTICS

*Courtesy: Mumbai International Airport*

**Figure 7-26: Illustration of New Modern Indian Style Architecture**

Acoustics of an environment has the ability to affect the way people behave. Excessive noise and poor speech intelligibility may lead to frustration on the part of the passengers in a confined area, such as the station building. The acoustic design of stations must provide a good aural environment, in which people can communicate clearly and easily, and the build-up of excessive noise is suppressed. Public address (PA) announcements must be easily heard and understood. A comfortable acoustic environment must also be provided for the employees in the non-public areas, such as in offices and administration areas. Necessary documentation to prove the standards shall be maintained so that the station's design achieves these goals.

### 7.16.1 Evacuation of Acoustics

Source of noises may be from,

(i) Train (train motor, A/c Unit..etc.)
(ii) Structures of stations (Generators, A/C, other equipment)

Passengers shall be able to communicate clearly and easily and the build-up of excessive noise shall be controlled to ensure good speech intelligibility. The noise reefing (NR) diagram & tables developed by international organization for standardization (ISO) shall be adopted for guidance.

**Table 7-13: Acceptable Noise Levels for Various Types of Spaces**

| Noise rating curve | Application |
|---|---|
| NR 25 | Concert halls, broadcasting and recording studios, churches |
| NR 30 | Private dwellings, hospitals, theatres, cinemas, conference rooms |

| Noise rating curve | Application |
|---|---|
| NR 35 | Libraries, museums, court rooms, schools, hospitals operating theaters and wards, flats, hotels, executive offices |
| NR 40 | Halls, corridors, cloakrooms, restaurants, night clubs, offices, shops |
| NR 45 | Department stores, supermarkets, canteens, general offices |
| NR 50 | Typing pools, offices with business machines |
| NR 60 | Light engineering works |
| NR 70 | Foundries, heavy engineering works |

**Table 7-14: Maximum Sound Pressure Level (dB)**

| Noise Rating - NR - Curve | Octave band mid-frequency (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 62.5 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| NR 0 | 55 | 36 | 22 | 12 | 5 | 0 | -4 | -6 | -8 |
| NR 10 | 62 | 43 | 31 | 21 | 15 | 10 | 7 | 4 | 2 |
| NR 20 | 69 | 51 | 39 | 31 | 24 | 20 | 17 | 14 | 13 |
| NR 30 | 76 | 59 | 48 | 40 | 34 | 30 | 27 | 25 | 23 |
| NR 40 | 83 | 67 | 57 | 49 | 44 | 40 | 37 | 35 | 33 |
| NR 50 | 89 | 75 | 66 | 59 | 54 | 50 | 47 | 45 | 44 |
| NR 60 | 96 | 83 | 74 | 68 | 63 | 60 | 57 | 55 | 54 |
| NR 70 | 103 | 91 | 83 | 77 | 73 | 70 | 68 | 66 | 64 |
| NR 80 | 110 | 99 | 92 | 86 | 83 | 80 | 78 | 76 | 74 |
| NR 90 | 117 | 107 | 100 | 96 | 93 | 90 | 88 | 86 | 85 |
| NR 100 | 124 | 115 | 109 | 105 | 102 | 100 | 98 | 96 | 95 |
| NR 110 | 130 | 122 | 118 | 114 | 112 | 110 | 108 | 107 | 105 |
| NR 120 | 137 | 130 | 126 | 124 | 122 | 120 | 118 | 117 | 116 |
| NR 130 | 144 | 138 | 135 | 133 | 131 | 130 | 128 | 127 | 126 |

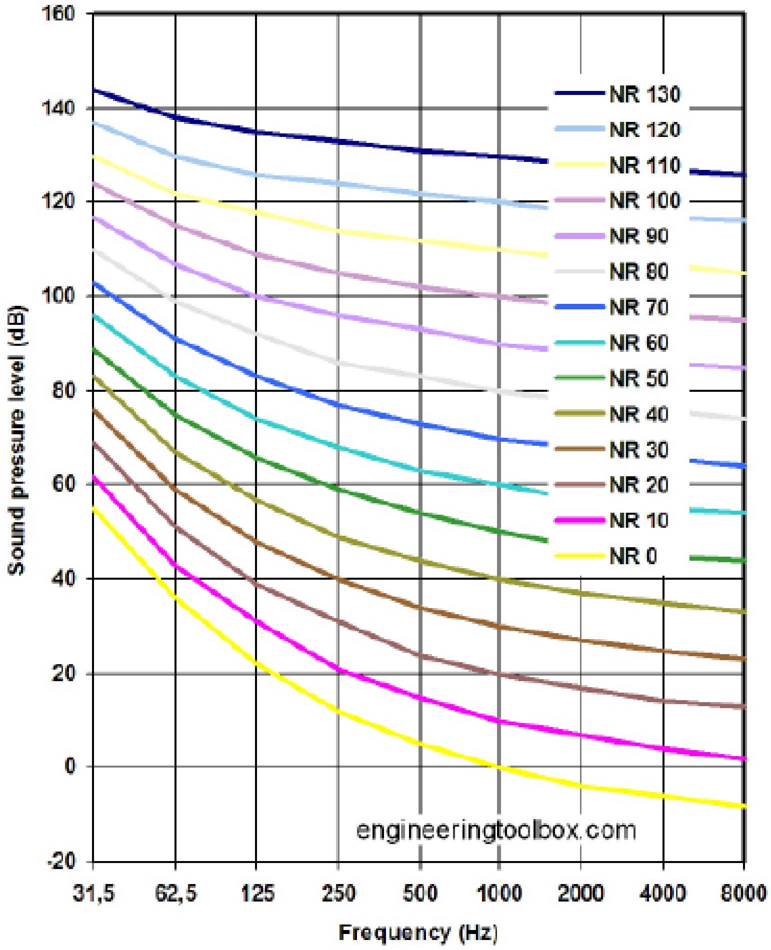



**Figure 7-27: NR - Noise Rating Diagram**

### 7.16.2 Reverberation Time (RT)

RT effects the comfort of passengers by its influence on perceived sound quantity and is the time required for sound pressure to decrease to a specified standard of 50-60 after the sound generation is stopped by the source.

Measures to control RT are,

(i) Sound absorption materials be used extensively.
(ii) Acoustical treatment base on type of ventilation system.
(iii) Structure borne noise to keep within limits.

#### 7.16.2.1 Acoustic material

Acoustical treatment is most effective when applied near the source of the noise. Designers shall take these into consideration in selecting acoustical materials and shall create solutions regarding easy accessibility to the materials for replacement.

Options may include:

(i) Cementitious spray-applied or trowel-applied acoustic materials (above reach of pedestrians).
(ii) Non-corrosive metal panels (with or without perforations) with wrapped acoustical material. Metal panels may have applied coating or natural brushed finish.
(iii) Rigid, cellular glass block.
(iv) Suspended acoustic tile (in nonpublic areas only).
(v) Cellular glass blocks (typically concealed behind metal panels).
(vi) Glass fiber blankets that are wrapped in close-weave glass cloth or other non-flammable sheeting.

## 7.17 EMERGENCY PREPAREDNESS

Emergency response program of the station and its personnel may involve, based on the volume of threat as per the following.

(i) Assessment of threat
(ii) Evacuation of vulnerability.
(iii) Availability of Police & Fire dept.

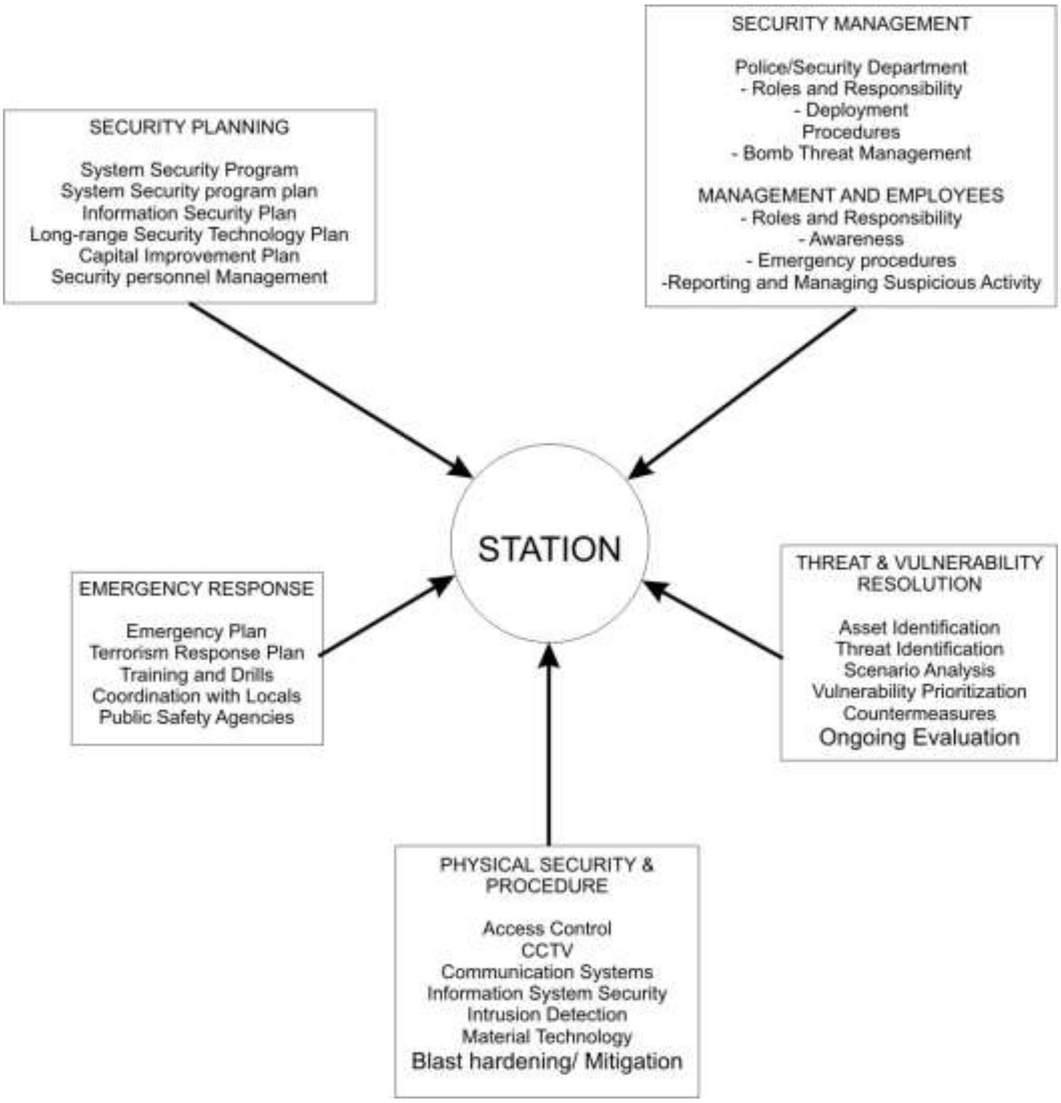



**Figure 7-28: Security and Emergency Preparedness Planning Guide**

## 7.18 STATION ART & ADVERTISINGS

Station design theme with architecture, art & advertising are integral part of station environment, its pleasing appearance and uniqueness.

### 7.18.1 Art as integral Component:

Art as integral part improves the culture and Environment. Heritage sites at the station if any, shall be well preserved and lit up. Sense of identification & memory of stations shall prevail up on.

### 7.18.2 Artist Collaboration

Artist to coordinate with architects & Engineers during all phases of construction is,

(i) Selection of glass, ceramic tiles etc.
(ii) Handmade elements, bronze etc.
(iii) Sound environment

### 7.18.3 Advertising

**7.18.3.1** Advertising need to be integrated with station design in a seamless manner. It should be used to enrich the overall ambience of stations. The guiding principles are,

(i) Plan for the advertisement and work as per the plan made.
(ii) Approval of text by the JV or SPV.
(iii) Unified design & Configuration is preferable.
(iv) Advertisements shall not interfere with passenger circulation
(v) Type& Size shall be standardized for uniformity to a large extent.
(vi) Advertising panels shall not be placed on gates and barriers.
(vii) Maintenance & replacement of advertising panels shall be easy and shall not hinder station working.

**7.18.3.2** Varieties of Advertisement

(i) Poster - Illuminated type.
(ii) Flip page
(iii) Wrap graphics
(iv) Information screens.
(v) Printed posters.

The above advertisements shall be considered at the following locations:

(i) All the platforms & corridors.
(ii) Unpaid areas, concourse etc.
(iii) Departure areas without hindrance to free movement.

## 7.19 SUSTAINABLE DEVELOPMENT & ENVIRONMENTAL CONSIDERATIONS

### 7.19.1 Goals

SilverLine make a commitment to comply with applicable environmental laws. Within all aspects of station planning and design, consideration shall include Sustainable Development. The Station Developer shall consider the following Five Pillars of environmental sustainability in all aspects for construction or operation of a new station:

(i) Energy Efficiency
(ii) Material and Resource Conservation
(iii) Indoor Environmental Quality (IEQ)
(iv) Best Operations and Maintenance
(v) Water Conservation and Site Management

The goal, in the application of these pillars, is to create an environmentally responsible heavy rail transit system that is appreciably ahead of current standards and practices when compared with a similar transportation system. The Railway Stations created by this effort shall become a model for a healthier, ecologically responsible environment where customers and K-Rail staff enjoy the benefits of a “green” environment.”

This section of Station and Area Development addresses the ways in which these Five Pillars could be applied to the planning and design of new Railway Stations. Each of the Five Pillars is addressed in turn with Requirements that are applicable to that aim. In order to relate the requirements to specific design groups, some of the possible strategies are enumerated under each pillar. Each of these strategies is linked to a more detailed description within the strategies section in relevant sections of this document as noted. By applying such strategies to the design of Railway Stations, the designer shall demonstrate the improvements and efficiencies of the design compared to existing standards or practice with respect to the Five Pillars.

### 7.19.2 Enforcement

Although significant success has been made in India in developing and enforcing environmental regulations in many areas, there still remain a number of areas that have not yet seen the promulgation of environmental standards and regulations. Many of these areas, such as the Indian Railways, have a high potential for adverse environmental impact if allowed to go unregulated. As the Indian Railways undertakes to modernize its operations and facilities, IR and the K-Rail must institute and enforce adequate environmental standards to provide for the protection of the health of its clients and staff as well as the environment.

#### 7.19.2.1 Environmental Impact Assessment

In response, the developer shall identify and quantify the environmental consequences of station redevelopment. The K-Rail shall comply with all applicable Indian laws and regulations to mitigate the environmental impact from the construction/renovation activities. It should conduct a preliminary analysis (Environmental Analysis) of the environmental impact of the proposed action(s) and identify alternatives to those actions. The K-Rail will need to prepare a detailed Environmental Impact Assessment (EIA) according the requirements of the Ministry of Environment and Forests in conjunction with local authorities having jurisdiction, addressing all areas identified as having environmental impacts. All appropriate categories/areas, such as air quality, noise, water quality, etc. are to be considered in the environmental analysis.

#### 7.19.2.2 Environmental Management System

The Silver line and the station developer shall have in place an Environmental Management System (EMS) to ensure the management support for mitigating the

environmental consequences of the operations at the world- class stations in conformance with ISO 14001. A policy statement from top management; identifying impacts and goals to mitigate them; assigning roles and responsibilities; providing appropriate and adequate training; preparing and maintaining documentation; monitoring and correcting environmental problems; and management review aimed at continuous future improvement, are the major elements of an ISO 14001 EMS, that has been widely adopted by the internationally both in government as well as the private sector, and is quite popular and well-recognized in India.

The Railway Station and the K-Rail staff should receive appropriate level of environmental training to ensure necessary knowledge, skill, and competency for understanding the environmental issues as and when they arise, and to provide solutions to meet the environmental regulations and requirements, thereby minimizing the adverse environmental consequences from the Railway Station Construction/Renovation operations.

### 7.19.2.3 Environmental Certification

The K-Rail shall obtain certification for the project under the Leadership in Energy and Environmental Design (LEED), Green Building Rating System (USA) an internationally accepted benchmark for the design, construction, and operation of high-performance energy efficient buildings. The K-Rail should aim for a Platinum level certification. If existing conditions associated with the construction of a structure over an operating railroad, make it infeasible to attain a LEED's Platinum certification the K-Rail shall document the reasons and in no case should the certification be less than the lowest LEED certification available. LEED promotes a whole building approach to sustainability by recognizing performance in the five pillars of environmental design and human health mentioned above and provides a road map to measure and document success for energy savings.

**7.19.2.4** Selection of appropriate building materials are important in sustainable design because of the long network in making it usable with least pollution. Reuse of construction waste and solid waste management are essential for the protection of human health and environment. Ozone depletion shall be avoided by eliminating refrigerants and solvent that contains CFC.

**7.19.2.5** Indoor Environmental quality relates to Indoor Air Quality (IAQ), Ventilation, Illumination, Vibration, Noise etc. Low level of volatile organic compounds (VOC's) are preferable and active or passive operational controls are necessary towards the same. Indoor space shall be integrated with outdoor environment to maximize daylight. Noise and vibration generated shall be minimized by installing quieter equipment and absorbing medium.

**7.19.2.6** Efficient operation and maintenance will be required to performance monitoring coupled with active progressive maintenance program. Since Railway Station operate 24X7 over 365 Days, materials used must be durable and easy to

clean and maintain. Finishes shall be easily maintainable and environmentally friendly. Periodical testing and calibration of building system to ensure efficiency needs to be carried out. Furniture, Fixtures & Fittings shall be of modular and of standard pattern.

**7.19.2.7** Supply of potable water supply as per standards established by WHO and IS 10500 -1991 is to be ensured at all the times. Wet wash requirement shall be minimized, and waterless urinals & low water usage flushing system shall be extensively used.

Rainwater harvesting and wastewater recycling methods shall be installed extensively. Proper management of storm and gray water and optimum use of treated water are essential to conserve the water.

Method & means to minimize the “heat island” and amount of thermal pollution into air & water shall be followed up.

## 7.20 APPROACH FOR TOD IMPLEMENTATION

### 7.20.1 Station Potential

All the 10 Silverline stations and surroundings have huge potential for hub of activities for both Rail users and related users. The development can occur in 3 parts

i) Urban development in a planned manner and by harmonization.
ii) Value Capture Financing.
iii) Railway related business hubs.

### 7.20.2 TOD in SilverLine stations is classified in three categories

**(1) Proximity Station Zone (PSZ):** The Influence area will be 500 meters on both side of 10 nos of Main Station defined in table 16.1.

**(2) Non-Proximity Station Zone (NPSZ):** The Influence area will be between 500 m-1000 m on both side of 10 nos of Main Station defined in table 16.1.

**(3) Non-Station Zone (NSZ):** The influence area will be identified land other than above defined zones. This will be a standalone Commercial Development zone irrespective of distance from SilverLine Stations.

The TOD development will be done for the below locations adhering to National TOD Policy. The Value Capturing Financing tools (except Green Surcharge on Fuel, Surcharge of private vehicle tax & Additional stamp duty & registration fee for property) will be applicable in influence zone (1000 m around the stations) of all stations irrespective of above classifications.

The detailed development plan is provided in chapter 16 of this DPR.

## 7.21 STATION DEVELOPMENT AS GREEN BUILDING

### 7.21.1 What is Green Building

Buildings are a major energy consuming sector in the economy. About 35 to 40% of total energy is used by buildings during construction. The major consumption of Energy in buildings is during construction and later in lighting or air-conditioning systems. This consumption must be minimized.

A green building uses less energy, water and other natural resources creates less waste & Green House Gases and is healthy for people during living or working inside as compared to a standard Building. Another meaning of Green Structure is clean environment, water and healthy living. Building Green is not about a little more efficiency. It is about creating buildings that optimize on the local ecology, use of local materials and most importantly they are built to cut power, water and material requirements.

#### 7.21.1.1 Advantages of Green Building

Green building offer some or all the following benefits to the building owner and building occupants:

(i) Reduced maintenance/ replacement costs over the life of the building
(ii) Energy conservation
(iii) Improved occupant health and productivity
(iv) Life cycle cost savings
(v) Lower costs associated with changing space configurations.
(vi) Greater design flexibility

### 7.21.2 Green Building Concept and Architecture Planning

To have Green Building concept, we looked after the following:-

(i) Optimum use of Energy or power
(ii) Water conservation
(iii) Solid and Water Waste management, its treatment and reuse
(iv) Energy efficient transport systems
(v) Efficient Building System Planning etc.

All the proposed stations have been planned and designed in such a manner that most of the green building concept may be adopted and IGBC ratings may be achieved.

## 7.22 RAKE LOADING FACILITIES AT STATIONS

For quick and easy loading & unloading of loaded trucks into wagons (RORO), 600 m long platform with ramps are proposed to be constructed as per the fig:7-18. The loading & unloading activities shall be both from ends as well as from the sides of the siding truck, through the ramped platforms.

The RORO platforms are proposed at

(i) Thiruvananthapuram (Kochuveli)
(ii) Ernakulam
(iii) Trissur
(iv) Kozhikode (West Hill)
(v) Kasaragod

In cases wherein the stations, platform, etc. are proposed to be located at elevated level, platforms for RORO loading are proposed at a faraway location but at ground level for easy manoeuvrability of the heavily loaded trucks. Flatter grades shall be maintained to ramp up from ground to the level of the elevated tracks along with provision of points & crossings adequately.

For expediting side loading into flat wagons to and fro movement of truck may become necessary.

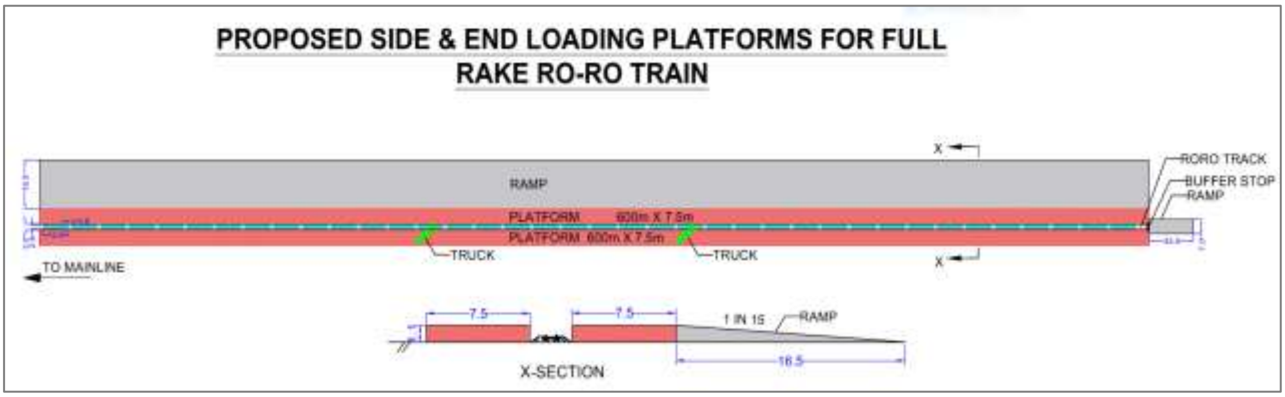



**Figure 7-29: Proposed side & end loading platforms for full rake RO-RO train**

## 7.23 Multi-Modal Integration at SilverLine Stations

### 7.23.1 General

The Multi-Modal Transportation Element provides strategic planning directions which will enhance the City's multi-modal transportation system. This section considers that K-Rail and the SPV for operations develops a variety of transportation alternatives including walking, peddling, automobile, public transport, etc. The result is a multi-modal transportation system that provides for an excellent quality of life.

In most of the cities and towns of Kerala, stations (Rail, bus, water transport) and services are not integrated efficiently with transport system of the city. But, previously few decades back, all KSRTC bus terminals in the main towns were planned and constructed in proximity to main railways stations as rail line were backbones to regional mobility Therefore, there is a necessity to provide seamless, sustainable, convenient safe and efficient mobility through an integrated multi modal transport system at cities and towns where SilverLine stations are proposed that enhances the quality of life for all by integrating these services and systems, dovetailing with the overall mobility needs of the people.

### 7.23.2 Composition of Multi Modal Integration

To build an efficient and reliable integration within the multiple modes of transportation, cities must achieve:

- Infrastructure and Operational Integration: Different transportation modes connected with each other physically and operationally viz., multimodal hubs, transfer/interchange stations
- Information Integration: Information system helps service providers achieve operational integration in addition to providing real-time information to passengers on various modes regarding connectivity option, routes, schedule and fare viz., developing Passenger Information System (PIS) either by displaying at the multimodal hubs, transfer/interchange stations or developing a mobile app for real-time information system.
- Fare Integration: integrated payment solutions like smart cards allow seamless access and payment across different modes viz., common smart fare cards usable for all public transport modes, parking, etc.,

Above all it needs a strong institutional setup to successfully achieve the integration with respect to infrastructure, operations, information and fare collection from different service providers.

### 7.23.3 Concept of Multi modal Integration

Multimodal integration is about moving passengers between modes – the process is people-centred and consists of moving users from one transport to another. However, good transport architecture celebrates the mundane process of circulation and movement by creating uplifting spaces that, through their scale, volume and clarity, 'reduce stress and anxiety among the travelling public' and also suggests ways of creating good transport system that fully exploits aspects of design to make way-finding clear and inter-relationship of transport facilities clear. Providing a pleasant journey for travellers will effect on how people view public transportation. Unless transport interchanges provide clarity of use and raise the spirit, it is difficult to realize shift from car use to public transport, no matter how well designed the new trains or buses may be.

All transit stations are required to be developed based on above concept for deriving success. Some objective of planning for multimodal integration are as below:

- Enhancing the pedestrian experience with a safe and more attractive walking environment;
- Maintaining a good level of service for transit access to the site for buses and other transit vehicles;
- Accommodating future access needs, which include vehicular traffic growth;
- Making transit use more convenient and attractive

While planning for multi-modality, a transportation hierarchy that gives priority to more resource efficient modes should be given priority over single occupant automobile

travel, particularly on congested urban corridors. This provides a basis for shifting emphasis in transport planning, road space allocation, funding and pricing to favour more efficient modes. Prioritisation would include be located closer to the terminal and reducing the number of conflict points and grade separations while accessing the terminal from that particular mode.

The general hierarchy adopted based on space efficiency as shown in figure below is:

1. Pedestrians
2. Non-motorized vehicles
3. Public Transit
4. Intermediate Public Transit / Para Transit (Auto-rickshaws and Taxis)
5. Pick & Drop (Kiss & Ride)
6. Park & Ride

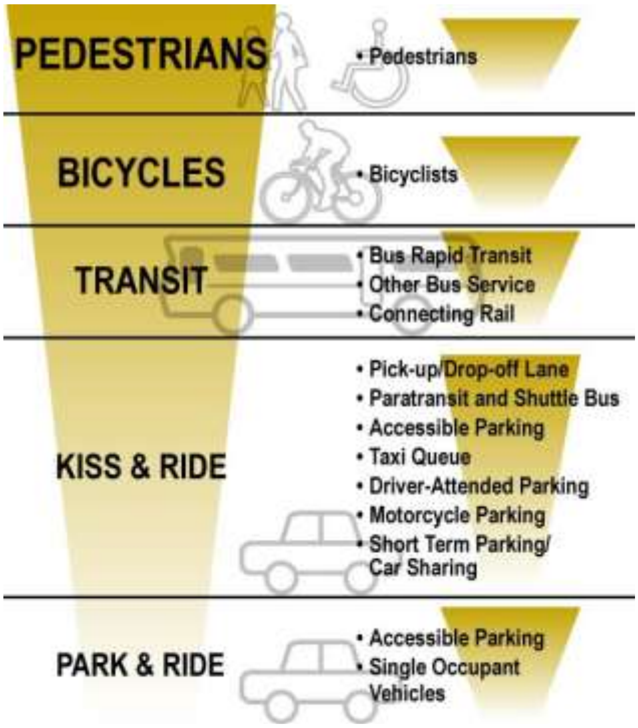



**Figure 7-30: Hierarchy of modes based on space efficiency**

Also, priority in planning of facilities is accorded maximum to pedestrians, followed by cyclists and users of other non-motorized modes, public transport, IPT, and lastly to drop off by private vehicles. Parking of private vehicles cannot be avoided but are discouraged at the station. Instead, park and ride facilities should be explored.

### 7.23.4 Intermodal Interchange Facilities

Planning for multimodal integration at a station looks into its accessibility by various modes such as walk, bicycles, IPT, public transit, private vehicles, etc. The transport infrastructure and facilities in the influence area of a station would have to be improved to enhance integration with other modes for safe and comfortable access and dispersal from each station.

Appropriate multimodal interchange facilities should be proposed at interfaces of two or more modes to reduce transfer penalties.

Within the interchange points, well planned pedestrian facilities like network of foot over bridges allows easy movement of passengers between the SilverLine, intercity bus, IPT and railway station. The other interchange facilities could include circulation facilities and adequate parking areas for various modes that are likely to come to important stations including city feeder, intra-city bus/ mini-bus (KSRTC and Private stage carriage buses). This will also add to the demand of the public transport system. The interchange facility provision for passengers will have to be made for peak demand at each station. The main issue is to make these interchanges convenient with minimum time penalty. Side by side or vertical interchange that involves minimum walking is the best suited design, and should be achieved as far as possible.

### 7.23.5 Planning Parameters to be considered for multi-modality

#### 7.23.5.1 Pedestrians

For the safety of all transit users, pedestrians should be provided the highest priority in station site and access planning. Station planning did not always provide priority access for pedestrians as a result of which pedestrians must cross railway platforms, parking lots, and vehicular lanes to reach the station entrance. For pedestrian pathways connecting to a station site, it is generally recognized that providing a safe and convenient walking environment that includes clear, un-fragmented, and integrated pedestrian paths to the station will encourage more customers to walk.

Some of the pertinent issues essential to consider when designing pedestrian access to a public transport station are shown in figure below.

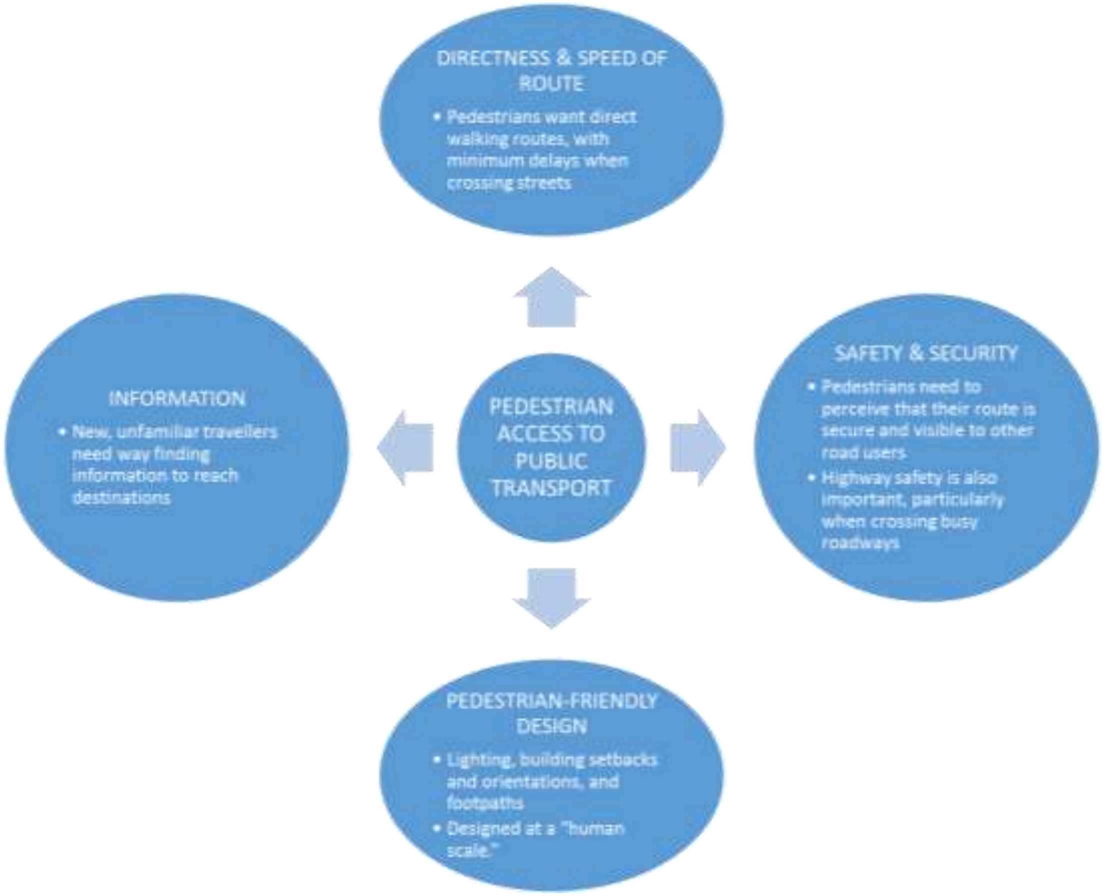



**Figure 7-31: Elements of pedestrian access to public transport**

*Source: TCRP*

#### 7.23.5.2 Non-motorised vehicles

To encourage the use of this space efficient and environmental friendly mode of access, non-motorised vehicles (NMVs - bicycles, bicycle sharing system etc.) are given priority over all motorised vehicular access. In the transit area, NMVs have the right-of-way over buses and automobiles, but do not have the right-of way over pedestrians.

While bicycle planning would act as a park and ride mode, bicycle share systems and cycle rickshaws would also be an access and feeder system to the terminal.

#### 7.23.5.3 Public Transit

All forms of public transit, whether rail based, or road based, generates a higher share of concentrated pedestrian activity on station sites. To facilitate the efficient and rapid access and egress of passengers, transit modes should be given priority over all other vehicular modes of access.

In the most efficient scenarios, bus based transit would have stoppages designed at the public access edge of the terminal site and rail based transit would either be integrated vertically through grade separated concourses or with a vomitory (entry/exit) opening directly at the public access edge.

In developed systems, with numerous modes of transit, integration of fares and ticketing may be useful in incentivising users to stay within the public transit system.

#### 7.23.5.4 Intermediate Public Transit

Intermediate Public Transit (IPT) (also known as Para Transit) is an extremely space efficient mode as compared to private vehicles. This is due to the fact that there is a quick turnaround time for such modes and unnecessary space is not wasted on parking. This allows a significantly higher number of passenger access and egress for the same space allocation.

In addition, in an Indian context, these often tend to have a higher occupancy and acting as an informal feeder system thus multiplying its benefits. A street-side lane for an auto-rickshaw stand, taxi stand and private shuttle buses dropping off or picking up passengers should be located closer to the station entrance than the Pick and Drop for private vehicles to incentivise these modes and afford these benefits to a larger proportion of users.

#### 7.23.5.5 Pick & Drop (Kiss & Ride)

A Pick and Drop (also known as Kiss & Ride) facility requires proximity to a station entrance for optimum function, it is afforded a higher access priority than Park & Ride access. Kiss & Ride areas include facilities for passenger drop-offs and pick-ups by automobile, as well as spaces for short-term parking. A curb side lane for automobiles dropping off or picking up passengers should be located closer to the station entrance than short-term parking.

#### 7.23.5.6 Park & Ride

Park & Ride facilities are generally used as all-day commuter parking. Park & Ride is considered an important transit mode share to Bus Terminals and should be accommodated. Available parking at stations can divert drivers from the city and region’s road system to transit and provides an opportunity for customers who may not be to use other modes to access a station. However, Park & Ride provides a low share of transit riders per vehicle and can detract from other more efficient modes of access. Therefore, Park & Ride ranks below all other modes of access in the station access hierarchy.

To dissuade from misuse and over usage of the parking facility both in terms of number and duration, the parking facility should be charged with a time based fee that increases telescopically. This would ensure a higher turnaround of the parked vehicles enabling an extension of the benefit afforded by the facility to a larger number of passengers. The charge levied should be more than the parking charge of the surrounding area and in line with the parking policy of the city to ensure that only legitimate passengers would be inclined to use the facility. In both in the provisioning and the pricing of the facility, it must be kept in mind that the Terminal is prime property attracting a high footfall and therefore of high rental sale value with a potential to serve as a public node of the city. Parking provisions must be kept at a minimum to afford

the benefit of the parking without having it over-power its position as a public place meant for citizens of the city and passengers who are visiting the city.

Existing rail and bus terminals would tend to be closer to the city centre and would have a higher proportion of access by shared modes. On the other hand, new regional terminals for SilverLine, Rail and Intercity Bus Terminals are proposed to be located outside the traffic burdened city centres in places where there is availability of free space for proper planning and development of the SilverLine station Area, TOD, platforms of buses and passengers' buildings. Therefore, for their intermodal operation it is vital to create the necessary connections of the terminal with the central district of the city and the nearby region by the available transport modes (de Boer & van Rossum, 2009).

### 7.23.6 Accessibility to a SilverLine station

A station is accessed by commuters who either walk to the station from nearby activity centres/ residential areas, or avail of a suitable mode as NMT, IPT, etc. Thus, in the immediate influence area of station, planning should be focused on seamless connectivity with the neighbourhood. Shaded pedestrian walkways and well-designed crossings should be provided, ensuring safety and minimization of conflict with vehicular movement, and convenient access to the nearest destination, such as a bus stop, metro station, etc. Facilities for pick up and drop off of passengers through IPT, stands for NMT shall render a station more accessible for commuters. A pedestrian friendly environment makes walking a pleasant, safe and efficient alternative to the use of motorized options.

Walking may not be a feasible option for trips originating outside the immediate zone. Infrastructure for NMT and IPT should be strengthened to provide an option for commuters to the station. Park and ride facilities may also be created for commuters, last mile connectivity to and from the station being provided through shuttle services.

For distances beyond 1.5 km, travel through NMT or walk becomes difficult and requires long time. Connectivity from the "Broader Zone" would be explored through feeder services to discourage the use personal vehicles.

Since some stations are situated close to each other, it is imperative that the intermediate or broad zone of influence of one station may overlap with the immediate zone of another. In such cases, hybrid facilities would have to be planned for, with the overall objective of improving access to the railway system.

Safe and convenient linkages shall be ensured for commuters to nearby transit nodes (such as a bus terminal, metro station) or activity centre.

### 7.23.7 Examples and Case Studies of Multi Modal Integration

Examples and case studies for successful multi modal transport integration are as mentioned below:

### London

London's overall public transport network is characterised by a well-established rail network complemented by an extensive bus network and a ferry network. These networks are integrated by multi-modal stations designed for ease of interchange for high volumes of passengers. At major stations, purpose built bus interchanges have been developed to be within walking distance of the railway and underground stations, often manned by bus station staff and furbished with real time information systems (e.g. Countdown – which shows the number of minutes until the next bus is due to arrive).

### Hong Kong

Hong Kong public transport services include railways, trams, buses, minibuses, taxis and ferries. This results in very high public transit mode share (90%) and very low vehicle ownership rates (50 vehicles per 1000 population). Hong Kong transport services are provided by several operators.

### Singapore

Singapore is considered an international leader in integrated multi-modal transport planning. It established the world's first area licensing and electronic road pricing systems and uses a quota system to limit vehicle ownership. The government makes continued investments in transport infrastructure.

The table below presents few of the successful multi-modal transport integration for various cities across the globe.

**Table 7-14: Examples of Multi-Modal Integration**

| City | Institutional Framework | Multimodal Infrastructure Elements | Info-Structure Elements | Integrated Payment Solutions |
|---|---|---|---|---|
| London | Transport for London (TFL) | Metro; Bus; Light Rail; Trams; Taxis | iBus; Web and mobile information systems | Oyester Smart Card |
| Paris | STIF | Metro; Tram; Bus | IMAGE project (real time traffic information) | Navigo Pass |
| Singapore | Land Transport Authority (LTA) | Metro (MRT); Bus; Light Rail; Taxis | Web-based and mobile (How2Go) information systems | EZ-Link; NETS FlashPay |
| Hong Kong | Transport Department, Govt. of Hong Kong | Metro; Bus | Next Train Mobile App, Passenger Information Display System | Octopus Smart Card |

| City | Institutional Framework | Multimodal Infrastructure Elements | Info-Structure Elements | Integrated Payment Solutions |
|---|---|---|---|---|
| New York City | New York Metropolitan Transportation Authority (MTA) | Metro; BRT; Local and Express Bus | MTA Bus Time | MetroCard |

*Source: EMBARQ Study*

### 7.23.8 Multimodal integration at SilverLine Stations

The SilverLine stations are proposed to be developed as multi-modal hubs to encourage public transport. The type of modes that may be integrated at each station is detailed out in the subsequent sections.

- Thiruvananthapuram Station: At this station, due to proximity of station with Kochuveli Railway station, southern railway will be connected. There is also proposal to implement an LRT or MetroLite as mass transit for the city, so LRT shall also be connected. Apart from the above, bays for SilverLine feeder service, pick & drop bays for city bus, intercity bus and provision for park & ride, IPT stands, pick & drop-off lane for app-based taxis etc., shall be provided.
- Kollam Station: At this station, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis etc., are proposed. For inter-city buses, pick & drop off bays for buses operating from Kollam and eastwards can also be provided.
- Chenganoor Station: At this station, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis etc., are proposed. The railways station and inter-city buses will be connected through SilverLine feeder service. Also, during Sabarimala season, parking of KSRTC special buses may also be provided at station.
- Kottayam Station: At this station, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, inter-city buses plying on NH 183, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis etc., are proposed. The railways station is not in the immediate proximity that can be connected physically, so it will be connected through SilverLine feeder service.
- Ernakulam Station: This station may be designated as another mobility hub for the region after Vytilla Mobility hub. At this location, proposed MRTS phase II, Water Metro, city bus, inter-city buses are proposed to be connected. Apart from the above, parking and bays for SilverLine Feeder service, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis etc., are also proposed to be connected.

Public Bicycle sharing (PBS) scheme is also implemented by KMRL at select location and can be extended to SilverLine stations to promote NMT.

- Trissur Station: Due to its proximity to existing railway station and KSRTC main bus stand, Rail and inter-city buses (operated by KSRTC) will be well connected and provisions for connecting the same through physical connectivity is proposed. Also, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis etc., are proposed. The SilverLine feeder may connect the service with Shaktan Thampuram bus terminal and bus terminal for Shornur and Palakad buses. There should also be provisions for pick & drop-off bays for long-route AC sleeper STU & private buses to Chennai and Bengaluru.
- Tirur Station: At this station, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis (if operated) etc., are proposed.
- Kozhikode Station: This station may be vertically connected with Kozhikode railway station due to its proximity to the existing station and platforms. There is also proposal to implement an LRT or MetroLite as mass transit for the city, and as per proposed alignment, it is proposed to connect existing railway station and bs terminals. So, LRT/MetroLite shall also be connected. Apart from the above, bays for SilverLine feeder service to other major catchments, pick & drop bays for city buses, and provision for park & ride, IPT stands, pick & drop-off lane for app-based taxis etc., shall be provided.
- Kannur Station: Due to its proximity to existing railway station and old bus stand, Rail and inter-city buses will be well connected and provisions for connecting the same through physical connectivity is proposed. Also, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis (if operated in future) etc., are proposed.
- Kasaragod Station: Due to its proximity to existing railway station, rail passengers will be well connected and provisions for connecting the same through physical connectivity is proposed. Also, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis (if operated in future) etc., are proposed.
- Kochi Airport Station: At this location, physical connectivity with Domestic and International terminal of CIAL is proposed along with one-point boarding and baggage counters. Also, parking and bays for SilverLine Feeder service, pick & drop bays for city bus, intercity buses (buses plying along the MC Road), provision for park & ride, segregated IPT stands for Autorickshaw and Taxi and pick-up & drop-off lane for app-based taxis etc., are proposed. The proposed

metro extension from Aluva to airport connectivity by KMRL, if implemented will also be connected physically through FoBs and travellators.

## 7.24 CONCLUSION

In SilverLine, total 11 stations will be operating and out of that 10 stations having potential for commercial development. The tentative details are mentioned in table 7-15 below,

**Table 7-15: Station Area Development**

| Proposed SilverLine Station | Total Area available (Ha) | Area with Rail SPV (Ha) | Potential Area with Land SPV | Property development Area with Rail SPV (sq.m) |
|---|---|---|---|---|
| Thiruvananthapuram | 42.09 | 16.77 | 25.32 | 258727 |
| Kollam | 249 | 53.67 | 195.33 | 256023 |
| Chengannur | 42.75 | 14.18 | 28.57 | 121853 |
| Kottayam | 256 | 15.51 | 240.49 | 290253 |
| Ernakulam | 239 | 16.97 | 222.03 | 260726 |
| Thrissur | 57.43 | 36.48 | 20.95 | 311852 |
| Tirur | 299.78 | 9.51 | 290.27 | 110452 |
| Kozhikode | 19.13 | 19.13 | 0 | 354252 |
| Kannur | 18.89 | 7.17 | 11.72 | 252052 |
| Kasaragod | 55.86 | 31.6 | 24.26 | 219126 |


Figure 7-32: Key plan showing location of proposed Thiruvananthapuram station


Figure 7-33: Key plan showing location of proposed Thiruvananthapuram RORO

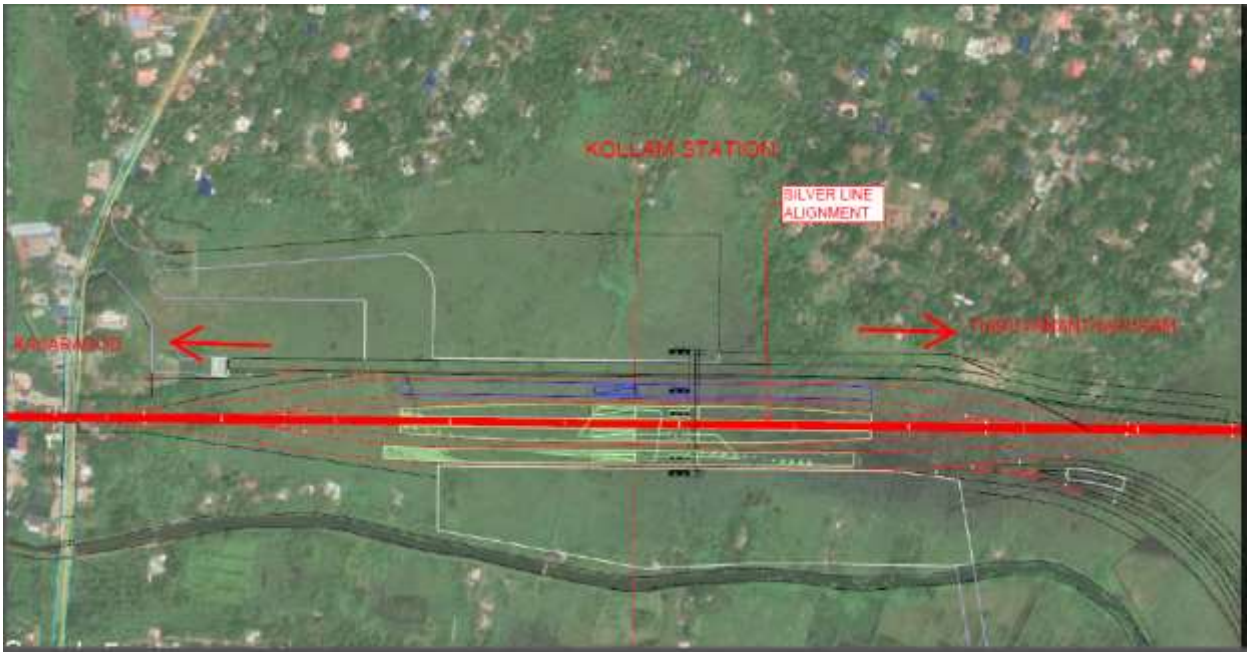



Figure 7-34: Key plan showing location of proposed Kollam station


Figure 7-35: Key plan showing location of proposed Kollam Depot

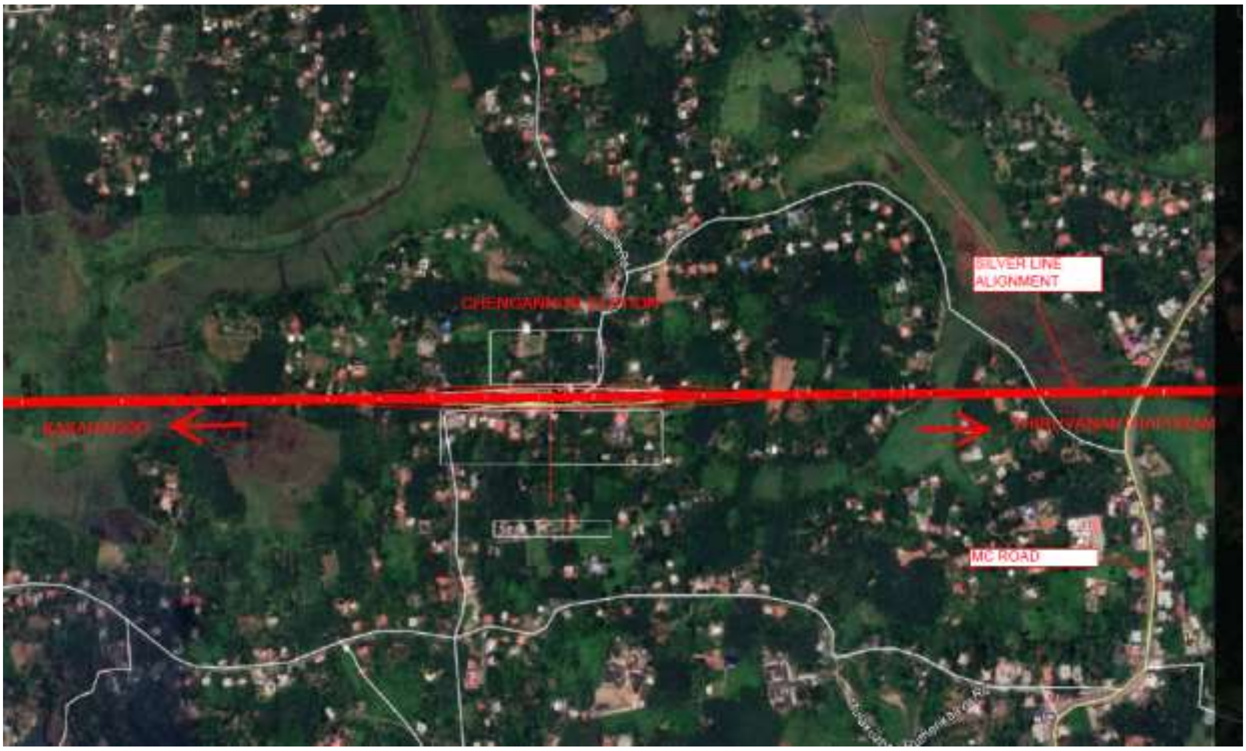



**Figure 7-36: Key plan showing location of proposed Chengannur Station**

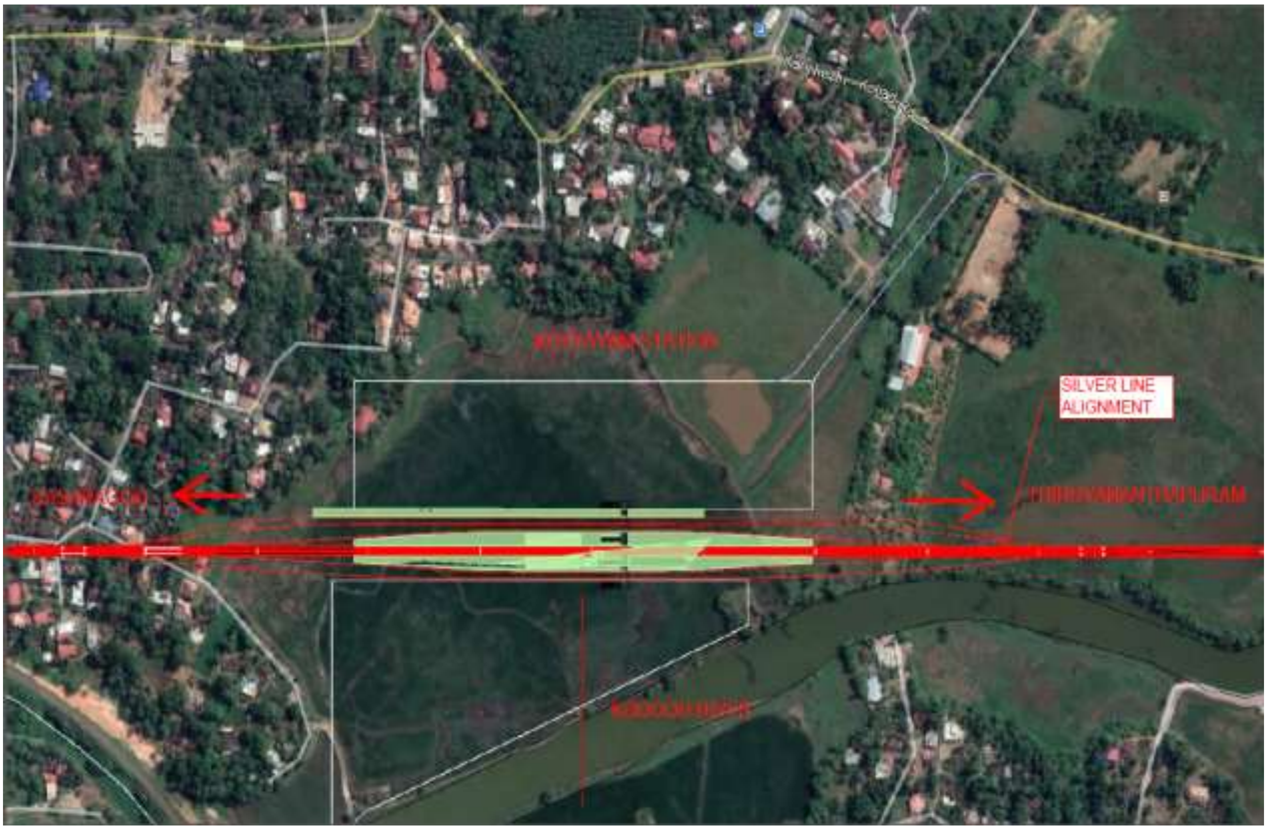



**Figure 7-37: Key plan showing location of proposed Kottayam Station**

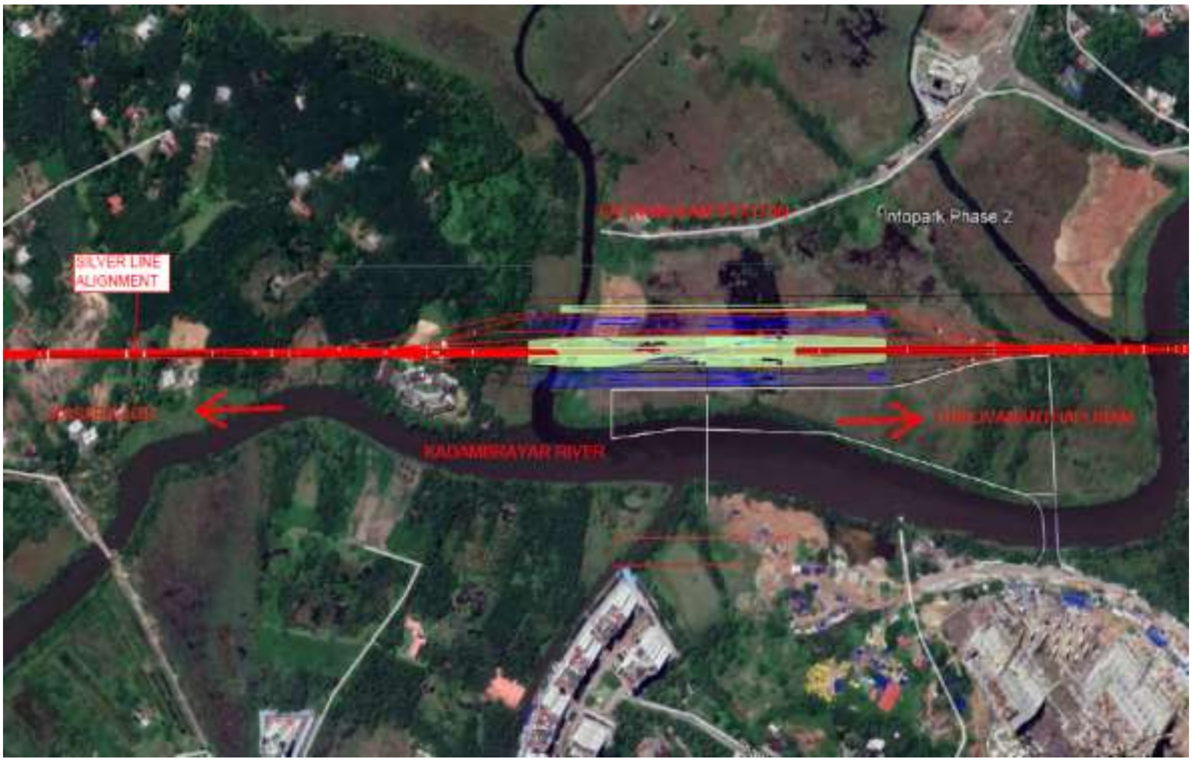



Figure 7-38: Key plan showing location of proposed Ernakulam Station


Figure 7-39: Key plan showing location of proposed Ernakulam RORO


**Figure 7-40: Key plan showing location of proposed Cochin Airport Station**


**Figure 7-41: Key plan showing location of proposed Thrissur RORO**


Figure 7-42: Key plan showing location of proposed Thrissur Station

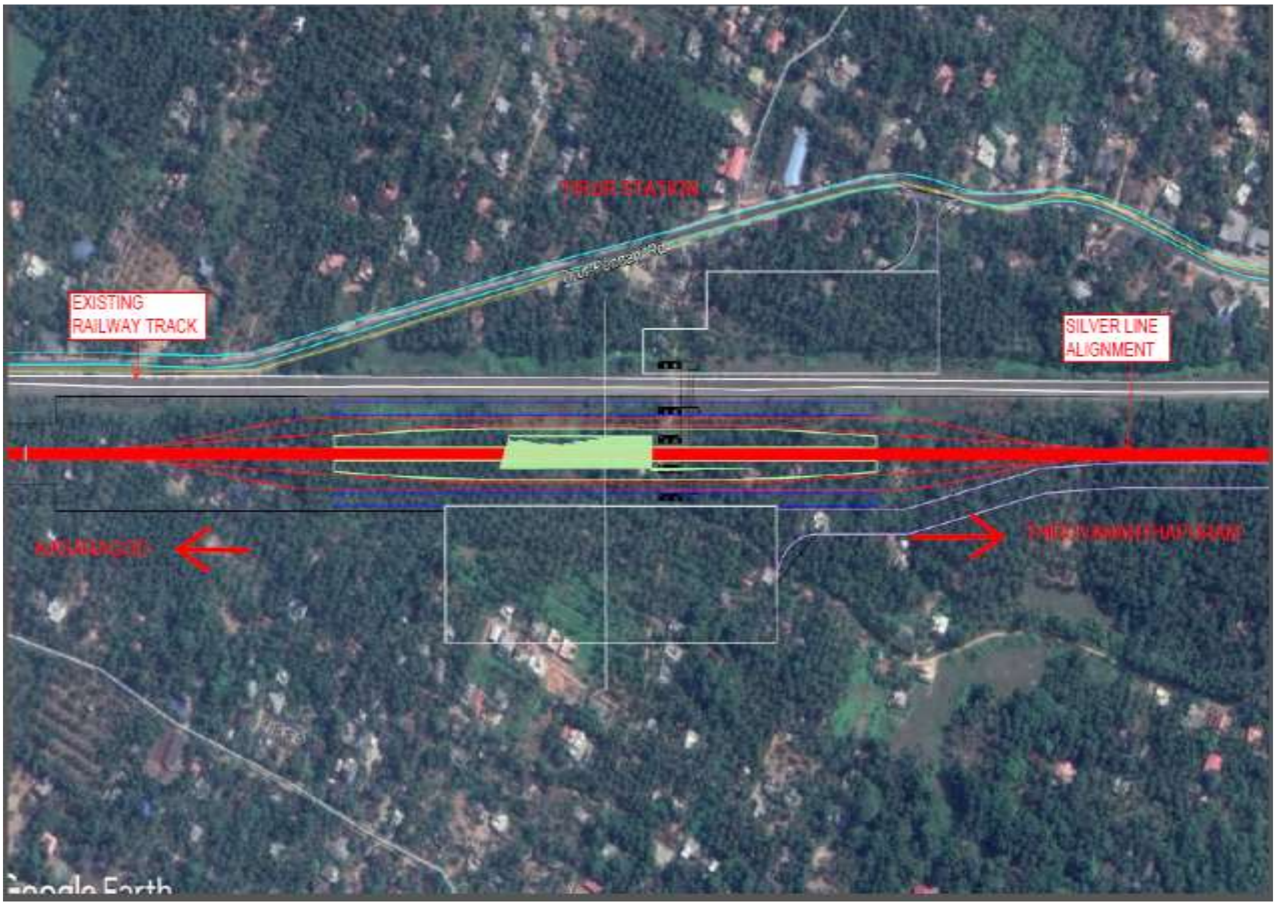



Figure 7-43: Key plan showing location of proposed Tirur Station


Figure 7-44: Key plan showing location of proposed Kozhikode Station


Figure 7-45: Key plan showing location of proposed Kozhikode RORO

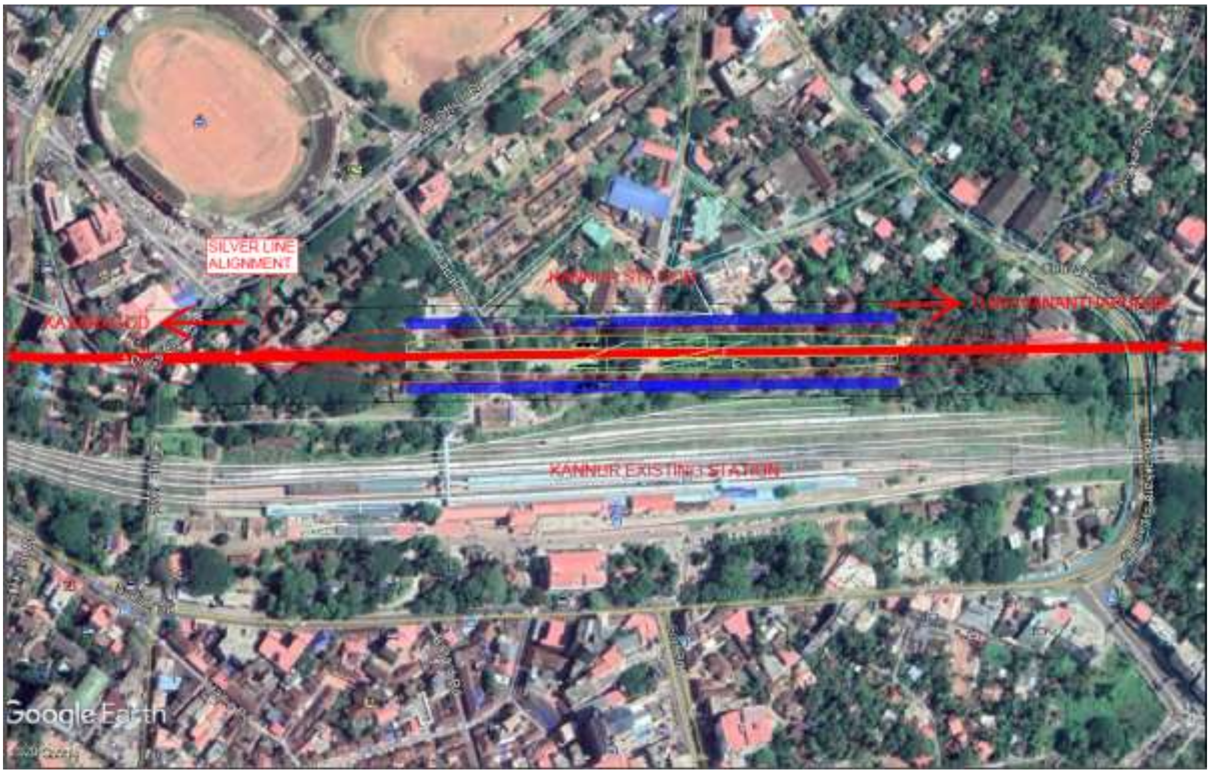



Figure 7-46: Key plan showing location of proposed Kannur Station


Figure 7-47: Key plan showing location of proposed Kannur RORO


Figure 7-48: Key plan showing location of proposed Kasaragod


Figure 7-49: Key plan showing location of proposed Kasaragod Depot

# DETAILED PROJECT REPORT

## SEMI HIGH SPEED RAIL CORRIDOR
## THIRUVANANTHAPURAM TO KASARAGOD

## VOLUME II - MAIN REPORT
## (PART B)

## CHAPTER 8
## CIVIL ENGINEERING

# 8 CIVIL ENGINEERING

## 8.1 GENERAL

This chapter deals with the civil engineering aspects of the Semi High Speed Rail project named as SilverLine and discusses about track structure and track supporting structures according to the geological conditions along the route, as mandated by the construction and other associated works necessary for the implementation of the project. It discusses the various options like At grade section, bank and cutting, cut & cover, elevated viaduct, tunnel, track structure, etc.

## 8.2 TRACK SUPPORTING STRUCTURES :-

### 8.2.1 Classification:

Track supporting structures can be classified into the following three categories:-

- At Grade : Embankment and Cutting
- Underground: Cut & cover and Tunnels
- Elevated: Viaduct and bridges

#### 8.2.1.1 Basic Policy Followed In Design Of Civil Structures:

1. All the structures are designed for loads of Semi High Speed trains and RORO type trains.
2. No level crossings across the SilverLine is allowed. On rail and road crossings, only grade separators in the form of ROB, RUB, RFO (Rail Flyover) are planned.
3. Various combination of loads such as the loaded trains in both the tracks, etc will be considered as per codes.
4. Station designs shall be modern and functional.
5. To reduce the width of land and increase the stability, it is proposed to construct the embankments with geo-mesh, geo-grid reinforcements.
6. In urban areas where land is costlier & scarce, it is proposed to construct embankment with precast self-supporting retainers/ retaining walls.
7. For bridges, standard spans of 6.10 m, 9.15 m, 12.20 m, 18.30 m etc. are proposed to be adopted to a large extent. Special / important bridges will be suitably designed.
8. For viaduct, to a large extent, 25 m or 30 m spans are proposed for facilitating mass construction. For other Spans site specific designs will be made.
9. For tunnels, a single large tunnel of approximate 80 sq. m of cross-sectional area to accommodate both tracks is planned. Tunnels will be provided when depth of cutting is very high, of the order of 20m and above.
10. Cut & cover method is proposed where depth of cutting is not very high or cuttings are unstable.

11. Reduction of lifecycle cost by avoiding steel bridges and providing maintenance free structure is planned.
12. In urban conglomeration, viaducts to reduce the land width and to maintain the available free paths & passages will be preferred.
13. Durable structures to cater to earthquake and other natural calamities shall be ensured.
14. Box type structures and U type girders to have more waterway and vent way clearances wherever required will be considered.

On the basis of alignment design of the SilverLine corridor made in Chapter 6 with techno-economic approach, following (Table 8-1) has been the combination of the proposed length of the Tunnels, Cut & cover, Cutting, Viaduct and embankment stretches on the entire 532.185km section length from Thiruvananthapuram to Kasaragod, whereas the route length ( centre to centre of end stations) is 529.45 km.

**Table 8-1: Proportion of Total Length for Proposed Structures**

| Sl. No | Type of Structures | Length (%age of Route length) |
|---|---|---|
| 1 | Tunnels | 11.528 Km (2.17%) |
| 2 | Bridges | 12.991 Km (2.44%) |
| 3 | Viaducts | 88.412Km (16.61%) |
| 4 | Embankments | 292.728Km (55.00%) |
| 5 | Cuttings | 101.737 Km (19.12%) |
| 6 | Cut & cover | 24.789Km (4.66%) |
| | **Total** | **532.185 (100%)** |

## 8.3 Construction Standards :-

- Civil infrastructures for rail lines are required to be designed and constructed keeping in view that these are to stand stable and durability to stand with all safety measures at least for 80 to 100 years in all weather conditions inclusive of natural calamities such as earthquake, storms and floods. Materials used are to be of superior and durable quality. All civil structures will be designed for the Design speed of 250 Kmph keeping future tilted coach trains in view. Clearances for tunnels and viaducts are to be provided for likely rolling stocks to be used at speeds required. Centre to Centre distance of the two tracks of

SilverLine is kept as 4.50 m which is inclusive of extra clearances required on the curves as per standards.

- Foundations for bridge structures and viaducts are to be provided with varying configurations depending on local ground conditions. Type of bridges, spans, height and impact protection for the high speed are to be ensured. By geotechnical exploration, it is evolved that this SilverLine will need pile foundations mostly at the locations where bank or cutting is not desirable due to site constraints.
- The minimum right of way for SilverLine corridor required by different structures, based on the dimensions required to accommodate the track , utility services and corresponding construction work, are listed in table 8.2.

**Table 8-2: Right Of Way For different structures**

| Sl. No. | Type of structures | ROW proposed |
|---|---|---|
| 1 | Embankment | 20m |
| 2 | Cutting | 25m |
| 3 | Cut and Cover | 20m |
| 4 | Tunnel | nil |
| 5 | Viaduct | 15m |
| 6 | Stations, yards and depots | As per yard plans and additional facilities planned. |

.

- **Viaducts :-**

Viaducts are limited to locations where habited areas are required to be crossed such as townships to reduce the disturbance to households. Efforts are also made to pass over important wet land pockets as much as possible.

The most suitable track supporting structure for a high speed rail line may be the elevated type when considering the topographical and hydrological nature of the Kerala State. Due to prolonged rainy season and intermittent rains throughout the year, At-grade (embankment / cutting) construction is likely to take more time. Viaduct does not require massive retaining walls, compound walls and other related works the construction of which may be affected by rains. Viaduct does not require any underpass at regular intervals as it does not divide the land use. However, elevated structures are generally costlier than embankment or cutting, given the ground conditions, foundations required are also deep type. Construction material like stone, metal and sand are in short supply in Kerala. Hence, to achieve an economical solution and in order to keep

the cost of project to a minimum, use of viaduct is limited to unavoidable stretches only.

- **Tunnels :-**

  Tunnels are limited to locations like hillocks where vertical grade requirements lead to very deep, unsafe and uneconomical cuttings and to very congested locations in major cities like Kozhikode where large number of properties exist. Tunnel construction will normally be done by using NATM due to the poor ground conditions and possibility of mixed soil conditions available in the region. The use of TBM is unlikely due to less length of the tunnels required to be constructed in hillocks. But for Kozhikode UG section of about 8km length, TBM may be the good option due to need of precise high-quality construction under a river and existing structures, located at close proximity to the sea. Cut & cover tunnels in high hills will be provided by cast in situ or precast methods.

- **Embankments & cuttings :-**

  Generally embankments and cuttings as in normal construction projects upto specified heights or depths depending on sub base/ base soil conditions and nature of hills.

- **Bridges :-**

  Major and minor bridges for water crossings and road over / under bridge for road crossings will be provided as per norms specified. Important and major bridges need thorough investigation in foundation and super structures for designs to satisfy all critical conditions.

Various types of geological / geotechnical conditions existing along the alignment and structures proposed are described in subsequent paragraphs.

## 8.4 GEOLOGICAL AND GEOTECHNICAL CONDITIONS ALONG THE ALIGNMENT:

### 8.4.1 Types of Soils in Kerala:

Kerala is endowed with a variety of soils due to the climate, topography, and vegetation characteristics. laterite and loams form the major soil types of Kerala. The other soil types developed as a result of agro-climatic variations include riverine and coastal alluvium, black soils, and problem soils like acid saline, hydromorphic, and greyish Onattukara as shown in **Figure below**.


**Figure 8-1: Types of soils in Kerala**

Various types of soils along with their characteristics are listed below;

a) Laterite Soil*:* Majority of area comprises this type of soil. Heavy rainfall and high temperature are conducive for laterization. Laterites are poor in available Nitrogen (N) and Phosphorus (P), low in water holding capacity and cation exchange capacity (CEC).

b) Coastal Alluvial Soil: Seen in the coastal tracts along the west, they have been developed from recent marine deposits. More permeability, low organic matter content, low CEC and less Water holding capacity characterizes the coastal alluvial soil.

c) Riverine Alluvial Soil: Seen along the banks of rivers, shows wide variation in physio-chemical properties depending on the nature of alluvium and the characteristic of the catchment area through which the river flows. Organic Matter, N and Potassium (K) are moderate.

d) Red Soil: The red color of soil is due to the presence of $Fe_2O_3$, mainly localized in southern parts of Thiruvananthapuram. The soil is almost homogeneous. Acidity ranges from 4.8 to 5.9. The gravel content is comparatively less. Low in essential nutrients and organic matter.

e) Forest Soil: A product of weathering of crystalline rocks under forest cover. Rich in organic carbon. pH acidic. Rich in N and poor in P.

### 8.4.2 Soil Quality:-

In general, the soils of Kerala are acidic, kaolinitic and gravelly with low CEC (Cation Exchange Capacity), low water holding capacity and high phosphate fixing capacity. Climate topography, vegetation and hydrological conditions are the dominant factors of soil formation. Based on the morphological features and physio-chemical properties, the soils of the State have been classified into red loam, laterite coastal alluvium, riverine alluvium, Onattukara alluvium, brown hydromorphic, saline hydromorphic, Kuttanad alluvium, black soil and forest loam.

### 8.4.3 Methodology adopted for soil investigation:-

- About eight boring rigs with all requisite equipment and accessories were mobilized at the work site. A team of technical personnel with skilled labors were also deputed.
- 127 boreholes of 150mm diameters for soil and NX size 75mm for rock strata were bored to a maximum depth of 60m below the existing ground level for this corridor of Semi High Speed Rail. The boreholes were made as per IS: 1892-1979.
- Undisturbed Soil samples were collected at a depth of 1.50 m below ground Level and further soil samples are done at 3.00m interval or change of Strata. The samples so collected were carefully sealed and numbered with full for identification and sent to the laboratory for conducting the required tests. Rock core samples were collected in wooden/Steel core boxes as per direction of Engineer.
- Standard Penetration Tests were conducted in the boreholes at regular intervals of 3m as per IS: 2131-1981. First SPT was conducted at 1.5m depth. In this test, the standard split spoon sampler is driven into the ground at the required depth by means of standard hammer of 63.5 Kgs weight, falling from a height of 75cm. Number of blows for the first 15cm is not taken into consideration because of possible disturbances or presence of settled, suspended matters at the bottom of the bore- holes. The total number of blows for the next 30cm depth of penetration is considered as SPT ‘N’ values.

### 8.4.4 Laboratory Investigations:-

The different laboratory tests conducted on the selected samples, recovered from the test boreholes, are listed in **Table 8-3**:

**Table 8-3: Laboratary tests conducted on selected samples**

| Sl. No | Laboratory Tests Conducted |
|---|---|
| 1 | Grain size analysis |
| | (a) Hydrometer analysis |
| | (b) Sieve analysis |
| 2 | Bulk and dry density and moisture content on UD samples. |
| 3 | Specific gravity of soil and Natural Density. |
| 4 | Chemical analysis of soil giving contents of sulphates, chlorides, pH value, etc. |
| 5 | Atterberg's limits |
| 6 | Consolidation test on clay samples giving relevant information as per IS: 2720 – XV –1986. |
| 7 | Collection of water samples and testing the same for pH value, sulphates, chlorides etc. |
| 8 | Direct shear test |
| 9 | Triaxial compressive strength test giving full test results including Mohr circle, stress – strain curve etc. |
| | a) Un-consolidation undrained test. |
| | b) Consolidation test on clay samples giving relevant information as per IS: 2720 – XV –1986. |
| 10 | Unconfined compressive strength test on clay soil samples as per IS: 2720 – X - 1973 |
| 11 | Testing of hard rock for Crushing strength, Density, Water Absorption Test and rock cutting etc. |
| 12 | Any other test/s as per project requirements. |

**IS Codes for Geotechnical investigations**

The relevant Indian standards conforming to which all the laboratory tests on soil samples conducted are listed in **Table 8.4**. All the samples were identified and classified as per IS: 1498.

**Table 8-4: The list of relevant laboratory tests on soil samples**

| Sl. No | Test Description | Relevant IS code |
|---|---|---|
| **A** | **Soil Tests** | |
| 1 | Natural Moisture Contents (N.M.C.) | IS:2720 (Part 2) |
| 2 | Bulk & Dry Unit Weight | IS:2720 (Part 2) |
| 3 | Mechanical Analysis (Hydrometer & Sieve) | IS:2720 (Part 4) |
| 4 | Atterberg Limits | IS:2720 (Part 6) |
| 5 | Tri-axial Tests (UU & CU) | IS:2720 (Part 11& 12) |
| 6 | Unconfined Compression Test (UC) | IS:2720 (Part 10) |
| 7 | Permeability test | IS: 2720 (Part 17) |
| 8 | Specific Gravity | IS:2720 (Part 3) |
| 9 | Direct shear test | IS: 2720 (Part 13) |
| 10 | Consolidation test | IS: 2720 (Part 15) |
| **B** | **Rock Tests** | |
| 1 | Water absorption | IS:2386 (Part 3) |
| 2 | Specific Gravity | IS:2386 (Part 3) |
| 3 | Unit Weight | IS:1303 (Part 1) |
| 4 | Crushing strength (UCS) | IS:9143 (Part 1) |
| 5 | Point load test | IS:8764 (Part 1) |
| **C** | **Chemical Tests** | |
| 1 | pH Value | IS:2720 (Part 26) |
| 2 | Chloride | IS:6925 (Part 1) |

| | | |
|---|---|---|
| 3 | Sulphate | IS:3025 (Part 24) |

### 8.4.5 General geology and related characteristics:-

a) Location: The Geo-technical site where investigation carried out along the SilverLine corridor.

b) Physiography and Climate: The State is generally having humid tropical wet climate with the temperature in summer varying between 24°C to 41°C and in winter between 22°C to 32°C. The period between January to April and September to December is generally dry whereas in June, July, October and November it is rainy season. The State has an average annual rainfall of 3107mm.

### 8.4.6 Field Investigations:-

Chainage 0/000 has been reckoned at the Centre Line of proposed Thiruvananthapuram station at Kochuveli. A total of 127 boreholes were drilled at an average distance of approximately 5km each and other important locations, all along the length of the proposed SilverLine corridor. Due to Change in alignment in Vadakara and Thalasseri area for about 57km, to keep alignment along the existing railway tracks, the data of 7 bore holes which were done along old route are discarded. Two bore holes done for ROB projects of K-Rail on existing level crossings are found appropriate and added in this report. Therefore, details of all relevant 122 boreholes are given below in **Table 8-5.** Soil investigation done at 122 bore holes revealed that at no place the black cotton soil has is encountered. However, it will have to be further ascertained on the basis of more detailed GT investigations done during execution and DDC stage.

**Table 8-5: Details of Boreholes**

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - 0+663 | GT-1 | 24.0 | - | - | 24.00 | 3.72 | 3.30 | 300 | Pile / Strip |
| 2 | 4+315.4 | GT-2 | 21.5 | - | - | 21.50 | 4.11 | 7.5 | 317 | Pile / Strip |
| 3 | 13+453.5 | GT-4 | 20.0 | - | - | 20.00 | 4.45 | 6.10 | 235 | Pile / Strip |
| 4 | 19+732.3 | GT-5 | 17.0 | - | 5 | 22.50 | 3.40 | 15.2 | 234 | Pile / Strip |
| 5 | 22+978 | GT-6 | 23.0 | - | - | 23.00 | 2.17 | 3.2 | 321 | Pile / Strip |
| 6 | 24+574.12 | GT-7 | 12.0 | - | 7.5 | 19.50 | 1.48 | 5.9 | 500 | Pile / Strip |
| 7 | 29+006 | GT-8 | 6.0 | 2.5 | 2.5 | 11.00 | 1.43 | 13 | 350 | Pile / Strip |
| 8 | 34+877.43 | GT-9 | 7.5 | 13 | - | 20.70 | 2.75 | 82.6 | 340 | Pile / Strip |
| 9 | 39+220 | GT-10 | 14.5 | 14 | - | 28.50 | 7.45 | 21.4 | 323 | Pile / Strip |
| 10 | 44+785 | GT-11 | 31.5 | 1.8 | 5 | 38.30 | 5.00 | 44.4 | 450 | Pile / Strip |
| 11 | 48+740.1 | GT-12 | 40.5 | - | - | 40.50 | 0.17 | 7.1 | 300 | Pile |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 50+419.6 | GT-13 | 28.7 | - | - | 28.70 | 3.60 | 3.3 | 250 | Pile |
| 13 | 53+352 | GT-14 | 27.0 | - | - | 27.00 | 0.00 | 12 | 430 | Pile |
| 14 | 56+272 | GT-15 | 27.5 | - | - | 27.50 | 1.60 | 4.5 | 350 | Pile |
| 15 | 58+200 | GT-16 | 41.0 | - | - | 41.00 | 1.80 | 20.2 | 450 | Pile |
| 16 | 60+588 | GT-17 | 43.5 | - | - | 43.50 | 1.20 | 11.1 | 450 | Pile |
| 17 | 63+421 | GT-18 | 38.5 | - | - | 38.50 | 3.60 | 53.8 | 450 | Pile |
| 18 | 67+068 | GT-19 | 12.1 | - | 5 | 17.10 | - | 21 | 450 | Pile |
| 19 | 70+010 | GT-20 | 28.5 | 8.25 | - | 36.75 | - | 39.6 | 180 | Pile |
| 20 | 70+717.6 | GT-21 | 12.4 | - | 5 | 17.40 | 0.40 | 3.6 | 450 | Pile |
| 21 | 74+800 | GT-22 | 40.5 | - | - | 40.50 | - | 39 | 450 | Pile |
| 22 | 78+263.5 | GT-23 | 19.0 | 3.1 | 5 | 27.10 | 4.50 | 15.9 | 400 | Pile |
| 23 | 84+264.3 | GT-24 | 7.5 | 20 | - | 27.50 | - | 3.7 | 280 | Pile |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 88+238.3 | GT-25 | 16.5 | 17 | - | 33.50 | 7.00 | 29.4 | 300 | Pile |
| 25 | 91+800 | GT-26 | 10.5 | 8 | - | 18.50 | 0.30 | 5.1 | 280 | Pile |
| 26 | 95+074.8 | GT-27 | 18.55 | - | 5 | 23.55 | 3.70 | 5.3 | 450 | Pile |
| 27 | 99+900 | GT-28 | 6.0 | 9.0 | - | 15.00 | - | 7.9 | 210 | Pile |
| 28 | 105+620.5 | GT-29 | 19.5 | 8 | - | 27.50 | 9.70 | 2.9 | 400 | Pile |
| 29 | 108+900 | GT-30 | 14.0 | - | 5 | 19.00 | 5.00 | 7.5 | 450 | Pile |
| 30 | 113+000 | GT-31 | 24.5 | - | - | 24.50 | - | 3.2 | 250 | Pile |
| 31 | 118+077 | GT-32 | 8.0 | - | 5 | 13.00 | - | 16.3 | 450 | Pile |
| 32 | 123+142 | GT-33 | 14.0 | - | 5 | 19.00 | - | 26.7 | 420 | Pile |
| 33 | 129+617.6 | GT-34 | 16.5 | - | 5 | 21.50 | - | 5.60 | 400 | Pile |
| 34 | 133+585.65 | GT-35 | 18.5 | - | - | 18.50 | - | 3 | 340 | Pile |
| 35 | 136+525 | GT-36 | - | - | 5 | 5.00 | - | 9.20 | - | Open |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 36 | 136+776.8 | GT-36B | 7.5 | - | 5 | 12.50 | - | 33.1 | 420 | Pile / Strip |
| 37 | 138+473.43 | GT-37 | 20.0 | - | 5 | 25.00 | - | 21.6 | 450 | Pile |
| 38 | 140+178.3 | GT-38 | 22.0 | 5 | - | 27.00 | 3.27 | 7.6 | 350 | Pile |
| 39 | 144+065.5 | GT-39 | 8.0 | - | 5 | 13.00 | 5.35 | 4.7 | 420 | Pile |
| 40 | 148+200 | GT-40 | 3.0 | - | 5 | 8.00 | - | 23.8 | - | Open |
| 41 | 154+000 | GT-41 | 19.5 | - | - | 19.50 | 2.62 | 23.6 | 350 | Pile / Strip |
| 42 | 157+821 | GT-42 | 6.0 | 3.04 | 5 | 14.04 | | 27.1 | 350 | Pile |
| 43 | 165+323 | GT-43 | 4.5 | - | 5 | 9.50 | 2.72 | 24 | - | Open |
| 44 | 170+100 | GT-44 | 11.0 | 6 | 5 | 22.00 | - | 5 | 450 | Pile |
| 45 | 173+121.71 | GT-44A | 6.0 | 7.54 | 5 | 18.54 | - | 9.4 | 450 | Pile / Strip |
| 46 | 173+716 | GT-44B | 7.5 | - | 5 | 12.50 | 3.50 | 57.1 | 460 | Pile / Strip |
| 47 | 174+081 | GT-45 | 1.5 | 1.5 | 5 | 8.00 | - | 9.6 | - | Open |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 179+626.4 | GT-46 | 2.6 | - | 5 | 7.60 | - | 18.7 | - | Open |
| 49 | 184+150 | GT-47 | 16.5 | 5 | - | 21.50 | - | 2.8 | 260 | Pile |
| 50 | 188+495 | GT-48 | 18.5 | - | - | 18.50 | 1.05 | 8 | 300 | Pile |
| 51 | 190+600 | GT-49 | 11.5 | 1.2 | 5 | 17.70 | 0.22 | 6.5 | 450 | Pile |
| 52 | 194+030 | GT-50 | 10.5 | 7.6 | 5 | 23.10 | 0.70 | 3.7 | 699 | Pile |
| 53 | 195+453 | GT-51 | 15.0 | 4.00 | 5 | 24.00 | 1.95 | 3.1 | 744 | Pile |
| 54 | 199+810 | GT-52 | 8.8 | - | 5 | 13.80 | 1.30 | 6 | - | Open |
| 55 | 204+133 | GT-53 | 12.5 | - | 5 | 17.50 | 5.72 | 26.2 | 486 | Pile |
| 56 | 207+900 | GT-54 | 28.5 | - | - | 28.50 | - | 15.7 | 585 | Pile |
| 57 | 210+520 | GT-55 | 10.5 | - | 5.3 | 15.80 | 1.00 | 2.9 | 710 | Pile / Open |
| 58 | 217+129.23 | GT-56 | 7.5 | 13.5 | - | 21.00 | 1.00 | 4.3 | 886 | Pile / Open |
| 59 | 222+342.3 | GT-57 | 8.1 | - | 5 | 13.10 | - | 3.7 | 472 | Pile |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 228+800 | GT-58 | 15.0 | - | 5 | 20.00 | - | 3.8 | 649 | Pile |
| 61 | 232+984 | GT-59 | 3.00 | - | 5 | 8.00 | 1.00 | 25.6 | - | Strip |
| 62 | 238+227 | GT-60 | 16.5 | 5 | - | 21.50 | 8.30 | 15.2 | 529 | Pile |
| 63 | 243+127 | GT-61 | 13.0 | - | 5 | 18.00 | 1.50 | 6.7 | 538 | Pile |
| 64 | 246+290 | GT-62 | 9.25 | 2.9 | 5 | 17.15 | 5.30 | 4.2 | 682 | Pile |
| 65 | 248+683 | GT-63 | 12.6 | - | 5 | 17.60 | 0.50 | 6.2 | 694 | Pile |
| 66 | 253+882.69 | GT-64 | 7.0 | - | 5 | 12.00 | 0.50 | 3.3 | 434 | Pile |
| 67 | 255+448.3 | GT-65 | 9.9 | - | 5 | 14.90 | 2.10 | 3.7 | 495 | Pile |
| 68 | 259+500 | GT-66 | 11.0 | 6 | - | 17.00 | - | 12.1 | 329 | Pile |
| 69 | 266+890 | GT-67 | 7.4 | - | 5 | 12.40 | 6.80 | 10.6 | 483 | Pile |
| 70 | 273+190 | GT-68 | 4.5 | - | 5 | 9.50 | - | 15 | - | Open |
| 71 | 277+900 | GT-69 | 10.2 | - | 5 | 15.20 | 1.80 | 15 | 568 | Pile |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 72 | 283+011.4 | GT-70 | 9.0 | - | 5 | 14.00 | 0.25 | 5.2 | 741 | Pile / Open |
| 73 | 288+642.2 | GT-71 | 10.5 | 1.7 | 5 | 17.20 | 0.50 | 14.4 | 512 | Pile / Open |
| 74 | 294+180.7 | GT-72 | 13.5 | 4.5 | 5 | 23.00 | 1.00 | 6.9 | 836 | Pile / Open |
| 75 | 298+047.7 | GT-73 | 8.1 | - | 5 | 13.10 | 6.20 | 2.5 | 441 | Pile / Open |
| 76 | 303+631 | GT-74 | 8.8 | - | 5 | 13.80 | 7.20 | 24.9 | 374 | Pile / Open |
| 77 | 307+575 | GT-75 | 26.4 | - | 4 | 30.40 | - | 3 | 313 | Pile / Open |
| 78 | 313+605 | GT-76 | 15.0 | - | 5 | 20.00 | 0.50 | 5.7 | 447 | Pile / Open |
| 79 | 317+110 | GT-77 | 11.5 | - | 5.25 | 16.75 | 0.30 | 11.6 | 392 | Pile / Open |
| 80 | 319+811 | GT-78 | 40.7 | - | 2 | 42.70 | 2.20 | 6.1 | 356 | Pile |
| 81 | 325+122 | GT-79 | 42.5 | - | 5 | 47.50 | 2.20 | 2.7 | 130 | Pile |
| 82 | 329+275.7 | GT-80 | 41.9 | - | 5 | 46.90 | 7.30 | 3.2 | 427 | Pile |
| 83 | 333+459 | GT-81 | 34.3 | - | 5 | 39.29 | 2.50 | 7.1 | 450 | Pile |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 84 | 337+810.7 | GT-82 | 20.5 | - | 5.1 | 25.60 | 1.60 | 12.7 | 450 | Pile |
| 85 | 342+129 | GT-83 | 17.5 | - | 5 | 22.50 | 0.80 | 11.2 | 350 | Pile |
| 86 | 348+550.83 | GT-84 | 19.5 | - | 4 | 23.50 | 1.00 | 2.8 | 350 | Pile |
| 87 | 353+782.42 | GT-85 | 29.8 | - | 5 | 34.80 | 1.60 | 3.2 | 450 | Pile |
| 88 | 356+376 | GT-86 | 22.5 | - | 5.1 | 27.60 | 0.50 | 2.9 | 400 | Pile |
| 89 | 357+400 | GT-86A | 19.5 | - | - | 19.50 | 1.00 | 3.4 | 110 | Pile / Strip |
| 90 | 357+669.3 | GT-87 | 38.0 | - | 5 | 43.00 | 1.00 | 2.8 | 480 | Pile |
| 91 | 357+978 | GT-87A | 23.5 | 4 | - | 27.50 | 2.95 | 3.4 | 180 | Pile / Strip |
| 92 | 363+490 | GT-88 | 25.5 | - | 6.5 | 32.00 | 1.00 | 68.6 | 400 | Pile |
| 93 | 366+700 | GT-89 | 16.5 | - | - | 16.50 | 4.00 | 12.8 | 260 | Pile |
| 94 | 370+771 | GT-90 | 11.0 | - | 5 | 16.00 | 1.50 | 6.7 | 450 | Pile |
| 95 | 375+359 | GT-91 | 16.0 | - | 5 | 21.00 | 1.50 | 16.1 | 260 | Pile |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 96 | 381+761.7 | GT-92 | 42.5 | - | - | 42.50 | 0.60 | 6.7 | 400 | Pile |
| 97 | 387+062.6 | GT-93 | 23.5 | - | 5 | 28.50 | 1.00 | 2.9 | 300 | Pile |
| 98 | 407+822 | GT-97 | 21.0 | - | 6 | 27.00 | 0.50 | 14.4 | 320 | Pile |
| 99 | 413+923 | GT-98 | 16.5 | - | 5.25 | 21.75 | 2.30 | 12.6 | 450 | Pile |
| 100 | 416+833 | GT-99 | 20.5 | - | - | 20.45 | 1.90 | 11.4 | 300 | Pile |
| 101 | *422+180* | *LC-225 BH-03* | *7* | *5* | *1.5* | *13.5* | *4.50* | - | *478* | *Pile* |
| 102 | *432+580* | *LC-234 BH-01* | *18* | *2* | - | *20.00* | *3.80* | - | *259* | *Pile* |
| 103 | 442+100 | GT-104 | 19.5 | 3 | 5 | 27.50 | 8.10 | 3 | 672 | Pile / Open |
| 104 | 448+635 | GT-105 | 15.0 | 20.5 | 5.5 | 20.50 | 1.00 | 9.4 | 417 | Pile / Open |
| 105 | 454+035 | GT-106 | 22.5 | 7.5 | 5 | 35.00 | 1.92 | 6 | 371 | Pile / Open |
| 106 | 458+417.7 | GT-107 | 10.5 | 14.5 | | 25.00 | 1.00 | 3 | 886 | Pile / Open |
| 107 | 465+900 | GT-108 | 33.0 | sample not retrieved | | 37.00 | 1.20 | 23 | 448 | Pile / Open |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 108 | 467+731 | GT-109 | 21.0 | 5 | - | 26.00 | 0.80 | 6.1 | 447 | Pile / Open |
| 109 | 475+215 | GT-110 | 27.0 | - | - | 27.00 | 0.50 | 6.5 | 478 | Pile / Open |
| 110 | 481+286 | GT-111 | 40.5 | - | - | 40.50 | 1.75 | 5.1 | 393 | Pile / Open |
| 111 | 485+464 | GT-112 | 44.0 | - | - | 44.00 | 2.70 | 2,6 | 373 | Pile / Open |
| 112 | 490+645 | GT-113 | 36.0 | - | - | 36.00 | 0.30 | 3.5 | 557 | Pile / Open |
| 113 | 493+331.5 | GT-114 | 43.0 | - | - | 43.00 | 0.50 | 15.5 | 477 | Pile / Open |
| 114 | 501+951 | GT-115 | 16.0 | 5 | 5 | 26.00 | 1.00 | 3.4 | 459 | Pile / Open |
| 115 | 507+110 | GT-116 | 15.0 | - | 5 | 20.00 | 1.00 | 7.4 | 394 | Pile / Open |
| 116 | 510+967 | GT-117 | 7.0 | 3 | 5 | 15.00 | 1.00 | 6 | 486 | Pile / Open |
| 117 | 514+216.5 | GT-118 | 6.0 | 4 | 8 | 18.00 | 1.00 | 3.7 | 419 | Pile / Open |
| 118 | 517+823 | GT-119 | 17.5 | 6.5 | - | 24.00 | 1.00 | 18.5 | 359 | Pile / Open |
| 119 | 519+965 | GT-120 | 10.5 | - | 5 | 15.50 | 0.50 | 10.3 | 497 | Pile / Open |

| Sl.no | Chainage | Bore-hole Identification no. | Depth in Soil (m) | Depth in Weathered Rock (m) | Depth in Rock (m) | Total Depth of Borehole (m) | Ground water Table Position below ground level (m) | RL of Borehole (m) | Pile Load Carrying Capacity for 1.20m dia pile(t) | Type of Expected Foundation |
|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 523+017 | GT-121 | 15.0 | 8 | - | 23.00 | 2.30 | 6.6 | 886 | Pile / Open |
| 121 | 528+683.3 | GT-122 | 21.0 | 9 | - | 30.00 | 1.00 | 2.8 | 315 | Pile / Open |
| 122 | Depot | GT-123 | 16.0 | 5 | - | 21.00 | 2.00 | 2.8 | 528 | Pile / Open |

### 8.4.7 Borehole wise brief description of GT investigations:-

- **Borehole No. 1 near Kochuveli**

**Location : 8°30'30.06"N, 76°54'8.64"E, Chainage : - 0 +663**

The subsoil stratum of borehole as shown in the details of borehole **Table 8-5** consists of sand and gravel from GL to 1.5m, light bluish grey silty fine sand from 1.5m to 12m, light yellowish grey silty fine to medium sand from 12m to 18m depth and whitish grey silty fine to medium sand from 18 m to 24m. The standard penetration tests (SPT) values reveal that the sub-soil stratum is loose up to 12m, medium dense from 12m to 18m and very dense up to 24m.

- **Borehole No. 2 near Station Kadavu**

**Location : 8°32'36.31"N, 76°52'28.75"E, Chainage : 4+315.4**

The subsoil stratum of borehole consists of silty sand from GL to 16m and brownish silty sandy sand with rock fragments from 16m to 21.5m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is dense up to 16m depth and very dense thereafter.

- **Borehole No. 4 near Murukkumpuzha**

**Location : 8°34'49.22"N, 76°51'36.30"E, Chainage : 13+453.5**

The subsoil stratum of borehole consists of reddish grey silty sand from GL to 7.5m, brownish grey silty sand from 7.5m to 13.5m and whitish grey silty sand from 15m to 20m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is loose to medium dense up to 7.5m, medium dense to dense from 7.5m to 13.5m and very dense from 13.5m to 20m.

- **Borehole No. 5 near Kunnuvaram**

**Location : 8°39'35.17"N, 76°48'19.10"E, Chainage : 19+732.3**

The subsoil stratum of borehole consists of reddish grey silty fine sand calcite mixed with moorum from GL to 4.5m, whitish grey fine to medium sand with calcite from 4.5m to 17.5m and whitish grey finely grained limestone from 17m to 22.5m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is loose up to 4.5m, medium dense to very dense from 4.5m to 17.5m and highly weathered weak limestone up to 22.5m depth.

- **Borehole No. 6 near Kollampuzha**

**Location : 8°41'19.20"N, 76°47'58.05"E, Chainage : 22+978**

The subsoil stratum of borehole consists of reddish yellow silty fine sand from GL to 23m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is loose up to 5.3m, medium dense from 5.3m to 16.5m and highly weathered weak limestone up to 23m depth.

- **Borehole No. 7 near Shankaramangalam**

**Location : 8°42'11.31"N, 76°47'56.59"E, Chainage : 24+574.12**

The subsoil stratum of this borehole consists of reddish grey sandy silty clay with moorum from GL to 12m depth and greyish gneiss from 12m to 19.5m. The standard penetration tests (SPT) values reveal that the sub-soil stratum is stiff from GL to 12m. From 12m to 14.5m, the stratum is highly weathered with weak gneiss. The borehole concludes at 19.5m with strata being very Hard Gneiss starting from 14.5m.

- **Borehole No. 8 near Chathampara**

**Location : 8°44'32.16"N, 76°48'27.56"E, Chainage : 29+006**

The subsoil stratum of borehole consists of blackish grey sandy silt from GL to 5.5m, brownish grey stone from 5.5m to 7.5m and greyish gneiss up to 12.5m depth. The standard penetration tests (SPT) values reveal that the sub - soil stratum was dense up to 7.5m and hard up to 12.5m depth. The borehole is incomplete as it is stopped without meeting the criteria.

- **Borehole No. 9 near Maruthikunnu**

**Location : 8°47'39.49"N, 76°47'59.40"E, Chainage : 34+877.43**

The subsoil stratum of borehole consists of silty sand with moorum from GL to 7m and greyish silty sand with rock fragments up to 20.5m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is loose to medium dense up to 7m and very dense from 7m to 20.5m depth.

- **Borehole No. 10 near Maruthikunnu**

**Location : 8°49'38.57"N, 76°46'50.95"E, Chainage : 39+220**

The subsoil stratum of borehole consists of reddish grey sandy silty clay calcite with moorum from GL to 10.5m, whitish grey fine to medium sand with calcite from 10.5m to 14.5m and whitish grey finely grained very weak limestone up to 19.5m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is stiff up to 10.5m, very dense from 10.5m to 14.5m and highly weathered weak limestone from 14.5m to 19.5m depth.

- **Borehole No. 11 near Karamcode**

  **Location : 8°50'47.15"N, 76°44'3.53"E, Chainage : 44+785**

  The subsoil stratum of borehole consists of reddish yellow silty laterite clay mixed with calcite from GL to 33.3m and gneiss from 33.3m to 38.3m depth. The standard penetration tests (SPT) values reveal that the sub-soil stratum is very stiff to hard up to 33.3m, and very hard up to 38.3m depth.

- **Borehole No. 12 near Ithikkara**

  **Location : 8°51'24.23"N, 76°42'1.70"E, Chainage : 48+740.1**

  The subsoil stratum of borehole consists of reddish yellow sandy silt from GL to 4m, dark grey sandy silty clay from 4m to 13.4m, coarse sand mixed with calcite from 13.4m to 25.5m and weathered greyish decomposed rock from 25.5m to 40.5m. The standard penetration tests (SPT) values reveal that the sub-soil stratum is loose up to 4m, very soft from 4m to 13.4m, medium dense from 13.4m to 25.5m and highly weathered rock from 25.5m to 40.5m.

- **Borehole No. 13 near Mylakkad**

  **Location : 8°51'50.48"N, 76°41'13.52"E, Chainage : 50+419.6**

  The subsoil stratum of borehole consists of greyish sandy clayey silt from GL to 10.9m and weathered greyish decomposed rock up to 28.7m. The standard penetration test (SPT) values reveal that the sub-soil stratum is loose up to 10.9m and weathered rock from 10.9m to 28.7m.

- **Borehole No. 14 near**

  **Location : 8°52'49.35"N, 76°39'57.95"E, Chainage : 53+352**

  The subsoil stratum of borehole consists of sandy clayey silt with sand from GL to 8m, laterite sand with pebbles from 8m to 21.5 and weathered greyish decomposed rock up to 27m. The standard penetration test (SPT) values reveal that the sub-soil stratum is loose up to 21.5m and weathered rock from 21.5m to 27m.

- **Borehole No. 15 near Thrikkovilvattom**

  **Location : 8°53'57.93"N, 76°39'21.83"E, Chainage : 56+272**

  The subsoil stratum of borehole consists of yellowish grey sandy silty clay from GL to 5.5m, weathered greyish decomposed rock from 5.5m to 10.1m, greyish sandy silty clay with gravels from 10.1m to 21m and weathered carbonaceous coal rock fragments up to 27.5m. The standard penetration test (SPT) values

reveal that the sub-soil stratum is stiff up to 5.5m, medium dense from 5.5m to 10.1m, very stiff from 10.1m to 21m and completely weathered up to 27.5m.

- **Borehole No. 16 near Mampuzha**

**Location : 8°55'11.03"N, 76°39'30.67"E, Chainage : 58+200**

The subsoil stratum of borehole consists of yellowish grey silty clay from GL to 10m, greyish clayey silty sand with mica from 10m to 27m, dark grey sandy silty clay with gravels from 27m to 35m and weathered carbonaceous coal rock fragments up to 41m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 10m, very dense from 10m to 27m, very hard from 27m to 35m and completely weathered up to 41m.

- **Borehole No. 17 near Kundara Road**

**Location : 8°56'21.74"N, 76°40'2.68"E, Chainage : 60+588**

The subsoil stratum of borehole consists of yellowish grey sandy silty clay with kankars from GL to 7.3m, whitish grey coarse sand mixed with calcite from 7.3m to 34.5m and whitish grey fine-grained calcite with limestone fragments up to 43.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is soft to firm up to 7.3m, medium dense to dense from 7.3m to 34.5m, and completely weathered up to 43.5m.

- **Borehole No. 18 near Thettikunnu**

**Location 8°57'46"N, 76°40'36"E, Chainage : 63+421**

The subsoil stratum of borehole consists of reddish yellow silty laterite clay mixed with calcite from GL to 10.9m, whitish grey coarse sand mixed with calcite from 10.9m to 33m and whitish grey calcite with limestone fragments up to 38.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is soft to firm up to 10.9m, very dense from 10.9m to 33m, and completely weathered up to 38.5m.

- **Borehole No. 19 near Mulavana**

**Location : 8°59'40.15"N, 76°41'6.99"E, Chainage : 67+068**

The subsoil stratum of borehole consists of grey silty clay mixed with kankars from GL to 10.1m, whitish grey calcite with limestone fragments from 10.1m to 12m and whitish grey limestone up to 17.1m. The standard penetration test (SPT) values reveal that the sub-soil stratum is soft up to 10.1m, completely weathered from 10.1m to 12m, and slightly weathered up to 17.1m.

- **Borehole No. 20 near Mathilakom**

**Location : 9° 1'11.87"N, 76°40'26.60"E, Chainage : 70+010**

The subsoil stratum of borehole consists of sand with gravel from GL to 4.5m, whitish grey calcite with limestone fragments from 4.5m to 25.5m and soft rock up to 36.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is soft up to 25.5m and slightly weathered up to 36.75m.

- **Borehole No. 21 near Kallada**

**Location : 9° 1'37.94"N, 76°40'13.92"E, Chainage : 70+717.6**

The subsoil stratum of borehole consists of grey silty clay mixed with kankars from GL to 12.4m and greyish gneiss up to 17.4m. The standard penetration test (SPT) values reveal that the sub-soil stratum is soft up to 12.4m, and very hard up to 17.4m.

- **Borehole No. 22 near Kunnathur**

**Location : 9° 3'45.04"N, 76°40'22.07"E, Chainage : 74+800**

The subsoil stratum of borehole consists of filled up materials from GL to 2m, sandy silty clay mixed with moorum from 2m to 9.5m, coarse sand mixed with calcite from 9.5m to 33m and whitish grey calcite with limestone fragments up to 40.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff to firm up to 9.5m, very dense from 9.5m to 33m, and completely weathered up to 40.5m.

- **Borehole No. 23 near Kadampanad**

**Location : 9°05'51"N, 76°40'26"E, Chainage : 78+263.5**

The subsoil stratum of borehole consists of sandy silty clay mixed with kankars from GL to 18m and gneiss up to 27m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff to firm up to 18m, and very hard from 18 to 27m.

- **Borehole No. 24 near Nooranad**

**Location : 9°09'17"N, 76°38'48"E, Chainage : 84+264.3**

The subsoil stratum of borehole consists of filled up materials from GL to 2m, sandy silty clay with moorum from 2m to 15m and calcite with limestone fragments up to 27.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff to firm up to 15m and completely weathered up to 27.5m.

- **Borehole No. 25 near Nooranad**

  **Location : 9°10'31.52"N, 76°38'17.39"E, Chainage : 88+238.3**

  The subsoil stratum of borehole consists of filled up materials from GL to 1.2m, silty laterite clay mixed with calcite from 1.2m to 21.5m and whitish grey calcite with limestone fragments up to 33.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff to hard from 2m to 21.5m and completely weathered up to 33.5m.

- **Borehole No. 26 near Pallimukkam**

  **Location : 9°12'26.55"N, 76°38'31.78"E, Chainage : 91+800**

  The subsoil stratum of borehole consists of reddish yellow sandy silty clay with moorum materials from GL to 11.5m and whitish grey calcite with limestone fragments up to 18.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is firm to stiff up to 11.5m and completely weathered up to 18.5m.

- **Borehole No. 27 near Punthala**

  **Location : 9°14'12.98"N, 76°38'31.78"E, Chainage : 95+074.8**

  The subsoil stratum of borehole consists of reddish yellow sandy silty clay with moorum materials from GL to 13m, whitish grey calcite with limestone fragments from 13m to 18.5m and gneiss up to 23.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is firm up to 13m, completely weathered from 13 to 18.5m and very hard from 23.5.

- **Borehole No. 28 near Karakkad**

  **Location : 9°16'38.9"N, 76°38'20.5"E, Chainage : 99+900**

  The subsoil stratum of borehole consists of dark grey clayey silty sand from GL to 7.5m and whitish grey calcite with limestone fragments from 7.5m to 15m. The standard penetration test (SPT) values reveal that the sub-soil stratum is loose up to 7.5m and completely weathered from 7.5 to 15m.

- **Borehole No. 29 near Arattupuzha**

  **Location : 9°19'46.7"N, 76°38'42.2"E, Chainage : 105+620.5**

  The subsoil stratum of borehole consists of clay with pebbles from GL to 1.5m, Laterite sand from 1.5m to 10.5m, clayey sand from 10.5m to 22.5m and Rock from

22.5m to 27.5m. The standard penetration test (SPT) values reveal that the sub - soil stratum is stiff up to 22.5m and completely weathered from 22.5 to 27.5m.

- **Borehole No. 30 near Nellimalai**

  **Location : 9°21'37.06"N, 76°38'31.33"E, Chainage : 108+900**

  The subsoil stratum of borehole consists of brownish silty fine sand from GL to 13m and Rock from 13m to 19m. The standard penetration test (SPT) values reveal that the sub-soil stratum is loose up to 13m and hard from 13 to 19m.

- **Borehole No. 31 near Kollapara**

  **Location : 9°23'39.87"N, 76°37'43.17"E, Chainage : 113+000**

  The subsoil stratum of borehole consists of brownish silty clay with gravel from GL to 16.5m and rock from 16.5m to 24.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is loose up to 16.5m and completely weathered from 16.5 to 24.5m.

- **Borehole No. 32 near Ottiyakuzhi**

  **Location : 9°26'23"N, 76°37'13"E, Chainage : 118+077**

  The subsoil stratum of borehole consists of brownish medium sand from GL to 8m and rock from 8m to 13m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 8m and hard from 8m to 13m.

- **Borehole No. 33 near Mamoodu**

  **Location : 9°28'49.82"N, 76°35'57.12"E, Chainage : 123+142**

  The subsoil stratum of borehole consists of brownish silty fine sand with gravel from GL to 13.5m and rock from 14m to 19m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 13.5m and hard from 14m to 19m.

- **Borehole No. 34 near Pathiaplli Kadavu**

  **Location : 9°31'28.55"N, 76°33'44.30"E, Chainage : 129+617.6**

  The subsoil stratum of borehole consists of brownish silty fine sand with gravel from GL to 6m, greyish silty clay from 6m to 16.5m and rock from 16.5m to 21.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 16.5m and hard from 16.5m to 21.5m.

- **Borehole No. 35 near Panjikadu**

  **Location : 9°33'13.01"N, 76°32'29.95"E, Chainage : 133+585.65**

  The subsoil stratum of borehole consists of brownish silty clay with gravel from GL to 10.5m and rock from 16.5m to 21.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 16.5m and hard from 16.5m to 21.5m.

- **Borehole No. 36 near Kanjikuzhi**

  **Location 9°34'55.4"N, 76°32'16.9"E, Chainage : 136+525**

  The subsoil stratum of borehole consists of Rock from GL to 5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is hard throughout the borehole.

- **Borehole No. 36B near Muttambalm**

  **Location : 9°35'11"N, 76°32'17"E, Chainage : 136+776.8**

  The subsoil stratum of borehole consists of reddish moorum with sandy clayey silt from GL to 4m, silty sand with gravels from 4m to 7.5m and rock from 7.5m to 12.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 7.5m and hard from 7.5m to 12.5m. The location ids proposed for tunnel.

- **Borehole No. 37 near Keezhukunnu, Meenachil River**

  **Location : 9°35'49.15"N, 76°32'15.46"E, Chainage : 138+473.43**

  The subsoil stratum of borehole consists of sand from GL to 3m, dark grey silty clay with organic matter from 4.5m to 9.0m, silty clay from 10.5m to 15m and rock from 7.5m to 12.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 7.5m and hard from 7.5m to 12.5m.

- **Borehole No. 38 near Vayanasala**

  **Location : 9°36'34.40"N, 76°32'49.20"E, Chainage : 140+178.3**

  The subsoil stratum of borehole consists of moorum with clay from GL to 6m, brownish grey silty sand from 6m to 16.5m, light bluish silty clay from 16.5m to 22m and rock up to 27m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 22m and completely weathered rock from 22m to 27m.

- **Borehole No. 39 near Peroor**

  **Location : 9°38'21.00"N, 76°33'56.00"E, Chainage : 144+065.5**

The subsoil stratum of borehole consists of boulder from GL to 4.5m, silty sand from 4.5m to 8m and rock up to 13m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 7.5m and hard from 8m to 13m.

- **Borehole No. 40 near Vallikadu**

  **Location : 9°40'32"N, 76°34'10"E, Chainage : 148+200**

  The subsoil stratum of borehole consists of moorum from GL to 1.5m. Boulder is present at 3m depth and rock from 3m to 8m. The standard penetration test (SPT) values reveal that the sub-soil stratum is hard throughout.

- **Borehole No. 41 near Kalathoor**

  **Location : 9°43'25.60"N, 76°32'57.00"E, Chainage : 154+000**

  The subsoil stratum of borehole consists of reddish moorum from GL to 10.5m and sand up to 19.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff throughout the borehole.

- **Borehole No. 42 near Thottuva**

  **Location : 9°45'20"N, 76°32'16"E, Chainage : 157+821**

  The subsoil stratum of borehole consists of reddish moorum clay from GL to 6m, soft medium rock from 6m to 9m and rock up to 14m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 6m, medium dense from 6m to 9m and hard from 9m to 14m.

- **Borehole No. 43 near Kunnapilly**

  **Location : 9°48'48.00"N, 76°30'14.00"E, Chainage : 165+323**

  The subsoil stratum of borehole consists of reddish moorum from GL to 4.5m, and rock up to 9.57m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff up to 4.5m and hard from 4.5m to 9.57m.

- **Borehole No. 44 near Mulakulam**

  **Location : 9°50'59.00"N, 76°28'49.00"E, Chainage : 170+100**

  The subsoil stratum of borehole consists of reddish brownish silty clay with moorum from GL to 11m, soft rock from 11m to 17m and rock from 17m to 22m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 10.5m, medium dense from 11m to 17m and hard up to 22m.

- **Borehole No. 44A near Pazhoor**

  **Location : 9°52'33.00"N, 76°28'23.00"E, Chainage : 173+121.71**

  The subsoil stratum of borehole consists of clayey silty sand from GL to 7.5m, soft rock from 7.5m to 13.5m and rock up to 18.54m. The standard penetration test (SPT) values reveal that the sub-soil stratum is stiff and hard throughout.

- **Borehole No. 44B near Pazhoor**

  **Location : 9°52'33.00"N, 76°28'23.00"E, Chainage : 173+716**

  The subsoil stratum of borehole consists of clayey silty sand with gravels from GL to 18m and rock up to 24m. The standard penetration test (SPT) values reveal that the sub-soil stratum is dense and hard throughout.

- **Borehole No. 45 near Pepathy**

  **Location : 9°53'1.93"N, 76°28'8.84"E, Chainage : 174+081**

  The subsoil stratum of borehole consists of laterite soil with clay from GL to 1.5m, soft rock from 2m to 3m and rock from 3m to 8.29m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 1.5m, medium dense from 1.5m to 3m and hard up to 8.29m.

- **Borehole No. 46 near Vettikkal**

  **Location : 9°54'54.50", 76°25'57.00"E, Chainage : 179+626.4**

  The subsoil stratum of borehole consists of filled up soil up to 1m depth, soft rock from 1m to 2.6m and rock from 2.6m to 7.6m. The standard penetration test (SPT) values reveal that the sub-soil stratum is medium dense up to 2.6m, and hard up to 7.6m.

- **Borehole No. 47 near Chottanikkara**

  **Location : 9°56'3.00"N, 76°23'49.60"E, Chainage : 184+150**

  The subsoil stratum of borehole consists of laterite soil from GL to 7.5m, soft rock from 7.5m to 16.5m and rock from 16.5m to 21m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 7.5m, medium dense from 7.5m to 16.5m and hard up to 21.5m.

- **Borehole No. 48 near Chitrapuzha**

  **Location : 9°57'37.01"N, 76°22'8.07"E, Chainage : 188+495**

  The subsoil stratum of borehole consists of mooram from GL to 4.5m,

granular soil with clay from 4.5m to 13.5m and brown granular sand from 13.5m to 18.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 13.5m and dense up to 18.5m.

- **Borehole No. 49 near Vettikavu**

  **Location : 9°58'32.00"N, 76°21'27.00"E, Chainage : 190+600**

  The subsoil stratum of borehole consists of reddish mooram from GL to 1.5m, silty clay from 1.5m to 12.7m and rock from 12.7m to 17.75m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 12.7m and dense from 12.7m to 17.75m.

- **Borehole No. 50 near Infopark Rd**

  **Location : 10° 0'14.20"N, 76°22'11.60"E, Chainage : 194+030**

  The subsoil stratum of borehole consists of reddish moorum from GL to 10.5m, soft rock from 10.5m to 18.1m and rock from 18.1m to 23.1m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 18.1m and hard from 18.1m to 23.1m.

- **Borehole No. 51 near Infopark phase 2**

  **Location : 10° 0'49.40"N, 76°22'41.60"E, Chainage : 195+453**

  The subsoil stratum of borehole consists of reddish moorum from GL to 15m, soft rock from 15m to 19m and rock from 19m to 24m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff and firm up to 19m and hard from 19m to 24m.

- **Borehole No. 52 near Pallikara**

  **Location : 10° 3'2.00"N, 76°23'27.00"E, Chainage : 199+810**

  The subsoil stratum of borehole consists of reddish moorum from GL to 1.5m, silty clay from 1.5m to 8m and rock from 8m to 13.8m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 8m and dense from 8m to 13.8m.

- **Borehole No. 53 near Nalaam Mile**

  **Location : 10° 5'21.00"N, 76°23'52.00"E, Chainage : 204+133**

  The subsoil stratum of borehole consists of reddish moorum from GL to 4.5m, silty clay from 4.5m to 12.5m and rock from 12.5m to 17.5m. The standard penetration

test (SPT) values reveal that the sub-soil stratum stiff up to 12.5m and dense from 12.5m to 17.5m.

- **Borehole No. 54 near Kuttamassery**

  **Location : 10° 7'6.00"N, 76°23'10.00"E, Chainage : 207+900**

  The subsoil stratum of borehole consists of silty sand from GL to 4.5m, coarse sand from 4.5m to 23.5m and sand from 23.5m to 28.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 6m, medium dense from 6m to 23.5m and dense up to 28.5m.

- **Borehole No. 55 near Neduvannoor**

  **Location : 10° 08'24"N, 76°22'43"E, Chainage : 210+520**

  The subsoil stratum of borehole consists of silty clay from GL to 4m, silty sand from 4m to 10.5m and hornblende biotite gneiss from 10.5m to 15.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum loose up to 10.5m, and hard up to 15.8m.

- **Borehole No. 56 near Peechanikadu**

  **Location : 10°11'41.60"N, 76°22'0.40"E, Chainage : 217+129.23**

  The subsoil stratum of borehole consists of silty sand from GL to 7.5m and soft rock from 7.5m to 21m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 7.5m and dense up to 21m.

- **Borehole No. 57 near Kallur**

  **Location : 10°13'36.40"N, 76°19'55.25"E, Chainage : 222+342.3**

  The subsoil stratum of borehole consists of brownish silty sand with clay from GL to 8.1m and rock from 8.1m to 13.1m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 6m, medium dense from 6m to 23.5m and dense up to 28.5m.

- **Borehole No. 58 near Asthamachira**

  **Location : 10°16'6.00"N, 76°17'43.01"E, Chainage : 228+800**

  The subsoil stratum of borehole consists of brownish silty clay with sand from GL to 15m and rock from 15m to 20.02m. The standard penetration

test (SPT) values reveal that the sub-soil stratum stiff up to 15m and hard from 15m to 20.02m.

- **Borehole No. 59 near Karoor**

  **Location : 10°18'19.00"N, 76°17'13.00"E, Chainage : 232+984**

  The subsoil stratum of borehole consists of laterite soil from GL to 3m and rock from 3.04m to 8.04m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 3m and hard from 3.04m to 8.04m.

- **Borehole No. 60 near Vallakunnu**

  **Location : 10°20'55.11"N, 76°15'23.11"E, Chainage : 238+227**

  The subsoil stratum of borehole consists of laterite clay from GL to 16.5m and soft rock from 16.5m to 21.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 16.5m and weathered from 16.5m to 21.5m.

- **Borehole No. 61 near Anandapuram**

  **Location : 10°22'59.96"N, 76°14'31.46"E, Chainage : 243+127**

  The subsoil stratum of borehole consists of laterite clay from GL to 13m and rock from 13m to 18m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 13m and weathered from 13m to 18m.

- **Borehole No. 62 near Porathissery**

  **Location : 10°24'05"N, 76°13'21"E, Chainage : 246+290**

  The subsoil stratum of borehole consists of laterite clay from GL to 10.15m, soft rock from 10.15m to 12.15m and rock from 12.15m to 17.15m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 10.15m and hard from 12.15m to 17.15m.

- **Borehole No. 63 near Ettumana**

  **Location : 10°25'6.32"N, 76°12'24.24"E, Chainage : 248+683**

  The subsoil stratum of borehole consists of laterite clay from GL to 12.6m, and rock from 12.6m to 17.6m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 12.6m and hard from 12.6m to 17.6m.

- **Borehole No. 64 near Chevoor**

  **Location : 10°27'17.64"N, 76°12'14.98"E, Chainage : 253+882.69**

The subsoil stratum of borehole consists of laterite clay from GL to 7m, and rock from 7m to 12m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 7m and hard from 7m to 12m.

- **Borehole No. 65 near Kanimangalam**

**Location : 10°28'41.27"N, 76°12'41.48"E, Chainage : 255+448.3**

The subsoil stratum of borehole consists of reddish moorum from GL to 5m, brownish grey silty clay from 5m to 9.9m and Biotite Schist from 9.9m to 14.9m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 9.8 and hard from 9.8m to 14.8m.

- **Borehole No. 66 near Thrissur Railway Station**

**Location : 10°30'43.17"N, 76°12'23.61"E, Chainage : 259+500**

The subsoil stratum of borehole consists of organic soil from GL to 10.5m and fragmented rock from 10.5m to 17m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 10.5m and weathered from 10.5m to 17m.

- **Borehole No. 67 near Kottekkad**

**Location : 10°34'19.62"N, 76°11'33.34"E, Chainage : 266+890**

The subsoil stratum of borehole consists of reddish moorum from GL to 2.5m, brownish silty clay from 2.5m to 7.5m and biotite schist from 7.5m to 12.4m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 7.5m and weathered yet strong from 7.4m to 12.4m.

- **Borehole No. 68 near Kollannur**

**Location : 10°36'37.06"N, 76° 8'54.06"E, Chainage : 273+190**

The subsoil stratum of borehole consists of reddish moorum from GL to 2m, weathered rock from 2m to 4.5m and hornblende biotite gneiss from 4.5m to 9.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 4.5m and hard from 4.5m to 9.5m.

- **Borehole No. 69 near Parannur**

**Location : 10°37'56.60"N, 76° 6'45.06"E, Chainage : 277+900**

The subsoil stratum of borehole consists of reddish silty clay from GL to 4m, brownish laminated clay with sand from 4m to 7m, residual soil from 7m to 10.2m and quartzite gneiss from 10.2m to 15.2m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 7m, dense from 7m to 10.2m and hard from 10.2m to 15.2m.

- **Borehole No. 70 near Ayyamparambu**

**Location : 10°39'57.23"N, 76° 4'46.76"E, Chainage : 283+011.4**

The subsoil stratum of borehole consists of laterite soil from GL to 3m, silty clay with fine sand up to 8m and quartzite gneiss from 8m to 14m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 7m, dense from 7m to 8m and hard from 8m to 14m.

- **Borehole No. 71 near Parapuram**

**Location : 10°42'32.39"N, 76° 3'10.00"E, Chainage : 288+642.2**

The subsoil stratum of borehole consists of brownish residual soil from weathered rock from GL to 2.5m, brownish silty clay with sand and organic matter from 2.5m to 11.20m and quartzite gneiss from11.2m to 17.2m. The standard penetration test (SPT) values reveal that the sub-soil stratum dense and stiff up to 11.2m and hard from 11.2m to 17.2m.

- **Borehole No. 72 near Alamcode**

**Location : 10°45'06.7"N, 76° 01'36.0"E, Chainage : 294+180.7**

The subsoil stratum of borehole consists of reddish brown moorum from GL to 3m, brownish silty clay from 3m to 15.5m, residual soil from weathered rock from 15.5m to 18m and quartzite gneiss from 18m to 23m. The standard penetration test (SPT) values reveal that the sub-soil stratum hard and stiff up to 18m and hard from 18m to 23m.

- **Borehole No. 73 near Edappal**

**Location : 10°47'06.1"N, 76°00'59.9"E, Chainage : 298+047.7**

The subsoil stratum of borehole consists of reddish brown moorum from GL to 5.5m, brownish silty clay with sand from 5.5m to 8.1m and quartzite gneiss from 8.1m to 13.1m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 8.1m and hard from 8.1m to 13.1m.

- **Borehole No. 74 near Maravanchery**

**Location : 10°49'55.9"N, 76°59'55.1"E, Chainage : 303+631**

The subsoil stratum of borehole consists of reddish brown moorum from GL to 3m, brownish silty clay with sand from 3m to 8.8m and quartzite gneiss from 8.8m to 13.8m. The standard penetration test values reveal that the sub-soil stratum stiff up to 8.8m and hard from 8.8m to 13.8m.

- **Borehole No. 75 near Bharathapuzha**

**Location : 10°51'46.46"N, 75°58'47.99"E, Chainage : 307+575**

The subsoil stratum of borehole consists of brownish silty clay with fine sand from GL to 5m, dark grey silty clay with organic soil from 5m to 7m, micaceous sand from 7m to 26.4m and mica schist up to 30.40m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 5m, soft from 5m to 7m, dense from 7m to 26.4m and hard from 26.4m to 30.4m.

- **Borehole No. 76 near Kattachira**

**Location : 10°53'47.9"N, 75°56'27.6"E, Chainage : 313+605**

The subsoil stratum of borehole consists of brownish silty clay with fine sand from GL to 15m and quartzite gneiss from 15m to 20m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 15m and hard from 15m to 20m.

- **Borehole No. 77 near Tirur**

**Location : 10°55'13.3"N, 75°55'12.2"E, Chainage : 317+110**

The subsoil stratum of borehole consists of brownish silty clay with gravels from GL to 5.5m, sandy silt from 5.5m to 11.5m and quartzite gneiss from 11.5m to 16.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum stiff up to 11.5m and hard from 11.5m to 16.5m.

- **Borehole No. 78 near Meenadathur**

**Location : 10°56'27.3"N, 75°54'22.8"E, Chainage : 319+811**

The subsoil stratum of borehole consists of brownish silty sand from GL to 8.4m, silty clay from 8.4m to 25m, silty micaceous sand from 25m to 30.5m, silty clay with sand from 30.5m to 37.5m, weathered residual soil from 37.5m to 40.7m and quartzite gneiss from 40.7m to 42.7m. The standard penetration test (SPT) values reveal that the sub-soil stratum dense and stiff up to 37.5m and hard from 37.5m to 42.7m.

- **Borehole No. 79 near Tanur**

**Location : 10°58'52.20"N, 75°52'50.9"E, Chainage : 325+122**

The subsoil stratum of borehole consists of brownish silty sand from GL to 7m, silty clay with sand from 7m to 42.5m and quartzite gneiss from 42.5m to 47.5m. The standard penetration test (SPT) values reveal that the sub-soil stratum dense and stiff up to 42.5m and hard from 42.5m to 47.5m.

- **Borehole No. 80 near Poorapuzha**

  **Location : 11°01'02.0"N, 75°52'12.1"E, Chainage : 329+275.7**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 4m, silty clay with sand from 7m to 15.5m, clayey sand from 15.5m to 25m, silty sand from 25m to 41.9m and hornblende biotite gneiss from 41.9m to 46.9m. The standard penetration test values reveal that the sub-soil stratum loose up to 4m, stiff from 4m to 41.9m and hard from 41.9m to 46.9m.

- **Borehole No. 81 near Parappangadi**

  **Location : 11° 3'9.02"N, 75°51'27.19"E, Chainage : 333+459**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 7m, silty clay with sand from 7m to 10m, sandy silty clay from 10m to 13m, silty clay from 13m to 15.5m, sandy clayey silt from 15.5m to 34.29m and rock from 34.29 to 39.29. The standard penetration test values reveal that the sub-soil stratum loose up to 7m, stiff from 7m to 34.29m and hard from 34.29m to 39.29m.

- **Borehole No. 82 near Vallikunnu Station**

  **Location : 11° 05'28.1"N, 75°51'06.2"E, Chainage : 337+810.7**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 5.5m, silty clay with decomposed from 5.5m to 7m, sandy silty clay from 7m to 20.5m, and rock from 20.5m to 25.6. The standard penetration test values reveal that the sub-soil stratum loose up to 5.5m, stiff from 5.5m to 20.5m and hard from 20.5m to 25.6m.

- **Borehole No. 83 near Kadalundi Bridge**

  **Location : 11° 7'31.46"N, 75°49'58.09"E, Chainage : 342+129**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 2.1m, silty clay with decomposed from 2.1m to 16m, sand with rock fragments from 16m to 17.5m and rock from 17.5m to 22.5m. The standard penetration test values reveal that the sub-soil stratum loose up to 2.1m, stiff from 2.1m to 17.5m and hard from 17.5m to 22.5m.

- **Borehole No. 84 near Chaliyar River**

  **Location : 11°10'52.5"N, 75°49'42.3"E, Chainage : 348+550.83**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 2.5m, silty clay with decomposed from 2.5m to 7m, silty sand from 7m to 19.5m and rock from 19.5m to 23.5m. The standard penetration test values reveal that the sub-soil stratum loose up to 2.5m, stiff from 2.5m to 19.5m and hard from 19.5m to 23.5m.

- **Borehole No. 85 near Meenchanda**

  **Location : 11°12'53.4"N, 75°47'41.0"E, Chainage : 353+782.42**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 7m, sandy clayey silt from 7m to 26.5m, sand with rock fragments from 26.5m to 29.8m and rock from 29.8m to 34.8m. The standard penetration test values reveal that the sub-soil stratum loose up to 4m, stiff from 4m to 41.9m and hard from 41.9m to 46.9m.

- **Borehole No. 86 near Kallayi River**

  **Location : 11°14'10.2"N, 75°47'11.1"E, Chainage : 356+376**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 7m, silty clay with gravels from 7m to 19.5m and hornblende biotite gneiss from 19.5m to 27.6m. The standard penetration test values reveal that the sub-soil stratum dense up to 7m, stiff from 7m to 19.5m and hard from 19.5m to 27.6m.

- **Borehole No. 86A near Kuttichira**

  **Location : 11°14'35"N, 75°46'48"E, Chainage : 357+400**

  The subsoil stratum of borehole consists of brownish silty sand with gravels from GL to 6m and snady clayey silt from 6m to 19.5m. The standard penetration test values reveal that the sub-soil stratum loose up to 6m and hard till 19.5m.

- **Borehole No. 87 near Kozhikode Station**

  **Location : 11°14'44.15"N, 75°46'47.78"E, Chainage : 357+669.3**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 6m, silty sand with gravels from 6m to 11m, rock from 11m to 14m, silty clay from 14m to 27m, clayey silt with gravel from 27m to 38m and hornblende biotite gneiss from 38m to 43. The standard penetration test values reveal that the sub-soil stratum loose up to 6m, stiff from 6m to 38m and hard from 38m to 43m.

- **Borehole No. 87A near Kozhikode Station**

  **Location : 11°14'54"N, 75°46'46"E, Chainage : 357+978**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 7.5m, silty clay with gravels from 7.5m to 15m, mud stone from 15.5m to 19m and sandy clayey silt from 19m to 27.5m. The standard penetration test values reveal that the sub-soil stratum is stiff throughout.

- **Borehole No. 88 near West Hill**

  **Location : 11°17'40.95"N, 75°45'40.75"E, Chainage : 363+490**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 5.5m, silty clay with gravels from 5.5m to 11m, sandy silty clay from 11m to 25.5m and rock from 25.5m to 32m. The standard penetration test values reveal that the sub-soil stratum is stiff up to 25.5m and hard from 25.5m to 32m throughout.

- **Borehole No. 89 near Vengali**

  **Location : 11°19'15.4"N, 75°45'00.9"E, Chainage : 366+700**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 5.5m, sandy silty clay with gravels from 5.5m to 25.5m and hornblende biotite gneiss from 25.5m to 32m. The standard penetration test values reveal that the sub-soil stratum loose up to 4m, stiff from 4m to 41.9m and hard from 41.9m to 46.9m.

- **Borehole No. 90 near Elathur**

  **Location : 11°21'20.4"N, 75°44'30.2"E, Chainage : 370+771**

  The subsoil stratum of borehole consists of reddish sandy clayey silt from GL to 7.5m, silty sand from 7.5m to 11m and rock from 11m to 16m. The standard penetration test values reveal that the sub-soil stratum is stiff from up to 11m and hard from 11m to 16m.

- **Borehole No. 91 near Pookkad**

  **Location : 11°23'39"N, 75°43'33"E, Chainage : 375+359**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 9m, silty clay from 9m to 16m and metamorphic rock from 16m to 21m. The standard penetration test (SPT) values reveal that the sub-soil stratum dense and stiff up to 16m and hard from 16m to 21m.

- **Borehole No. 92 near Koilandy**

  **Location : 11°26'37"N, 75°41'43"E, Chainage : 381+761.7**

The subsoil stratum of borehole consists of brownish silty clay from GL to 22.5m, sand with rock fragments from 22.5m to 28m, clayey sandy silt from 28m to 34.5m and sand with rock fragments from 34.5m to 42.5m. The standard penetration test values reveal that the sub-soil stratum dense up to 28m, stiff from 28m to 34.5m and hard from 34.5m to 42.5m.

- **Borehole No. 93 near Moodadi**

  **Location : 11°28'18.9"N, 75°39'25.4"E, Chainage : 387+062.6**

  The subsoil stratum of borehole consists of brownish silty sand with clay from GL to 11.5, sandy silt with gravels from 11.5m to 23.5m and rock from 23.5m to 28.5m. The standard penetration test values reveal that the sub-soil stratum dense up to 11.5m, stiff from 11.5m to 23.5m and hard from 23.5m to 28.5m.

- **Borehole No. 97 near Madapally Railway Road**

  **Location : 11°38'38.0"N, 75°34'38.0"E, Chainage : 407+822**

  The subsoil stratum of borehole consists of brownish sandy silty clay from GL to 10.5m, silty sand from 10.5m to 18m, sand with rock fragments from 18m to 21m and quartzite gneiss from 21m to 27m. The standard penetration test values reveal that the sub-soil stratum firm to stiff up to10.5m, dense from 10.5m to 21m and very hard from 21m to 27m.

- **Borehole No. 98 near Orkatteri**

  **Location : 11°40'49.1"N, 75°33'07"E, Chainage : 413+923**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 5.5m, sandy silty clay from 5.5m to 16.5m and quartzite gneiss from 16.5m to 21.75m. The standard penetration test values reveal that the sub-soil stratum stiff up to 5.5m, dense from 5.5m to 16.5m and very hard from 16.5m to 21.75m.

- **Borehole No. 99 near Mahe River**

  **Location : 11°42'22.1"N, 75°32'57.8"E, Chainage : 416+833**

  The subsoil stratum of borehole consists of brownish sandy silty clay from GL to 2.5m, silty sand from 2.5m to 12.5m and sand with rock fragments from 12.5m to 20.45m. The standard penetration test values reveal that the sub-soil stratum stiff up to 12.5m and very dense from 12.5m to 20.45m.

- **Borehole No. 03 of LC 225 / KRDCL near Vayalalam**

  **Location : 11°43'50.92"N, 75°30'42.26"E, Chainage : 422+180**

The subsoil stratum of borehole consists of brownish sand from GL to 3.5m, sandy silty clay from 3.5m to 6.5m, weathered rock from 6.5m to 12m and rock up to 13.5m. The standard penetration test values reveal that the sub-soil stratum loose up to 3.5m, stiff from 3.5m to 6.5m, weathered from 6.5m to 12m and hard from 12m to 13.5m.

- **Borehole No. 01 of LC 234 / KRDCL near Muzhapilangadi**

  **Location : 11°47'58.64"N, 75°26'53.76"E, Chainage : 432+580**

  The subsoil stratum of borehole consists of brownish sand from GL to 9m,silty sand from 9m to 18m and weathered rock from 18m to 20m. The standard penetration test values reveal that the sub-soil stratum varies from loose to dense up to 18m, and weathered from 18m to 20m.

- **Borehole No. 104 near Edapally Panavel Highway**

  **Location : 11°51'46.8"N, 75°24'39.2"E, Chainage : 442+100**

  The subsoil stratum of borehole consists of brownish silty clay with moorum from GL to 5.5m, silty clay with sand from 5.5m to 9m, boulder from 9m to 13.5m, residual soil from weathered rock from 13.5m to 19.5m, mica laminated schist from 19.5m to 22.5m and quartzite gneiss up to 27.5m. The standard penetration test values reveal that the sub-soil stratum stiff up to 19.5m, weathered from 19.5m to 22.5m and hard from 22.5m to 27.5m.

- **Borehole No. 105 near Kannur Station**

  **Location : 11°53'03"N, 75°21'46"E, Chainage : 448+635**

  The subsoil stratum of borehole consists of brownish moorum from GL to 7.5m, residual soil from weathered rock from 7.5m to 15m and sandstone up to 20.5m. The standard penetration test values reveal that the sub-soil stratum dense up to 7.5m, weathered from 7.5m to 15m and hard from 15m to 20.5m.

- **Borehole No. 106 near Valapattanam River**

  **Location : 11°55'46.5"N, 75°20'47.9"E, Chainage : 454+035**

  The subsoil stratum of borehole consists of filled up ground from GL to 1.6, silty sand with 1.6m to 22.5m, mica laminated schist from 22.5m to 30m and quartzite gneiss up to 35m. The standard penetration test values reveal that the sub-soil stratum dense up to 22.5m, weathered from 22.5m to 30m and hard from 30m to 35m.

- **Borehole No. 107 near Irinave Railway Crossing**

  **Location : 11°58'44"N, 75°19'45"E, Chainage : 458+417.7**

  The subsoil stratum of borehole consists of micaceous sand from GL to 10.5m and mica schist from 10.5m to 25m. The standard penetration test values reveal that the sub-soil stratum dense up to 10.5m and weathered from 10.5m to 25m.

- **Borehole No. 108 near Mundappuram**

  **Location : 12°00'30.2"N, 75°16'53.7"E, Chainage : 465+900**

  The subsoil stratum of borehole consists of silty clay from GL to 1.6m, micaceous silty sand from 1.6m to 8m, silty clay with sand from 8m to 16.5m, silty sand from 16.5m to 28.5m and silty clay from 28.5m to 33m. The standard penetration test values reveal that the sub-soil stratum dense up to 28.5m and stiff from 28.5m to 33m. Samples from 33m to 37m were not retrieved.

- **Borehole No. 109 near Pazhayangdi**

  **Location : 12°01'22.8"N, 75°16'24.9"E, Chainage : 467+731**

  The subsoil stratum of borehole consists of micaceous silty sand from GL to 4.5m, silty clay with sand from 4.5m to 13.5m, residual soil from weathered rock from 13.5m to 21m and Sandstone from 21m to 26m. The standard penetration test values reveal that the sub-soil stratum loose up to 4.5m, stiff from 4.5m to 13.5m and dense up to 26m.

- **Borehole No. 110 near Kunghimangalam**

  **Location : 12°04'15.0"N, 75°13'38.7"E, Chainage : 475+215**

  The subsoil stratum of borehole consists of micaceous silty sand from GL to 16.5m and residual soil from weathered rock from 16.5m to 27m. The standard penetration test values reveal that the sub-soil stratum loose up to 7.5m, dense from 7.5m to 16.5m and weathered up to 27m.

- **Borehole No. 111 near Payyannur**

  **Location : 12° 6'30.56"N, 75°11'26.33"E, Chainage : 481+286**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 4.5m and micaceous sand from 4.5m to 40.5m. The standard penetration test values reveal that the sub-soil stratum loose up to 4.5m and dense from 4.5m to 40.5m.

- **Borehole No. 112 near Thrikkaripur Railway Station**

  **Location : 12° 8'36.32"N, 75°10'33.20"E, Chainage : 485+464**

  The subsoil stratum of borehole consists of reddish silty sand from GL to 14.15m, boulder from 14.15m to 17m, gravelly sand from 17m to 23m, silty clay with sand from 23m to 28m and coarse sand up to 44m. The standard penetration test values reveal that the sub-soil stratum dense throughout.

- **Borehole No. 113 near Chandera**

  **Location : 12° 11'24.0"N, 75°09'38.8"E, Chainage : 490+645**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 6m, silty clay with sand from 6m to 9m, silty sand with gravels from 9m to 19m, silty clay with sand from 19m to 22m and silty sand with gravels up to 36m. The standard penetration test values reveal that the sub-soil stratum is dense throughout.

- **Borehole No. 114 near Thejaswini River**

  **Location : 12°14'9.54"N, 75° 8'53.27"E, Chainage : 493+331.5**

  The subsoil stratum of borehole consists of brownish silty sand from GL to 15.5m, silty clay with sand from 15.5m to 30.5m, residual soil from weathered rock from 30.5m to 36m and mica laminated schist up to 43m. The standard penetration test values reveal that the sub-soil stratum is dense throughout.

- **Borehole No. 115 near Padannakkad**

  **Location : 12°16'11.21"N, 75° 6'47.25"E, Chainage : 501+951**

  The subsoil stratum of borehole consists of brownish silty sand with gravels from GL to 7.5m, silty clay with sand from 7.5m to 10.5m, silty sand with gravels from 10.5m to 16m, mica schist from 16m to 21m and quartzite gneiss up to 26m. The standard penetration test values reveal that the sub-soil stratum is dense throughout.

- **Borehole No. 116 near Kanghangad**

  **Location : 12°18'43.6"N, 75°05'18.6"E, Chainage : 507+110**

  The subsoil stratum of borehole consists of brownish silty sand with gravels from GL to 10m, silty clay with sand from 10m to 15m and gneiss up to 20m. The standard penetration test values reveal that the sub-soil stratum is loose up to 10m, dense from 10m to 15m and hard till 20m.

- **Borehole No. 117 near Madiyan**

  **Location : 12°20'32.02"N, 75° 4'32.67"E, Chainage : 510+967**

  The subsoil stratum of borehole consists of brownish silty sand with gravels from GL to 7m, mica schist from 7m to 10m and quartzite gneiss up to 15m. The standard penetration test values reveal that the sub-soil stratum is dense up to 7m, weathered from 7m to 10m and hard till 15m.

- **Borehole No. 118 near Chithari Bridge**

  **Location : 12°21'59.24"N, 75° 3'32.23"E, Chainage : 514+216.5**

  The subsoil stratum of borehole consists of brownish silty sand with gravels from GL to 3m, silty clay from 3m to 6m, residual soil from weathered rock from 6m to 10m and mica schist up to 18m. The standard penetration test values reveal that the sub-soil stratum is loose up to 3m, stiff till 10m and weathered from 10m to 18m.

- **Borehole No. 119 near Pallikkare**

  **Location : 12°23'34.58"N, 75° 2'25.54"E, Chainage : 517+823**

  The subsoil stratum of borehole consists of laterite soil from GL to 13.5m, residual soil from weathered rock up to 17.5m and mica schist till 24m. The standard penetration test values reveal that the sub-soil stratum is stiff up to 17.5m and weathered from up to 24m.

- **Borehole No. 120 near Malankunnu**

  **Location : 12°24'31.8"N, 75°01'47.7"E, Chainage : 519+965**

  The subsoil stratum of borehole consists of silty sand from GL to 4.5m, silty clay from 4.5m to 5.5m, silty sand from 5.5m to 8.5m, silty clay from 8.5m to 10.5m and quartzite gneiss till 15.5m. The standard penetration test values reveal that the sub-soil stratum is loose and stiff alternatively throughout.

- **Borehole No. 121 near Udma**

  **Location : 12°26'08.1"N, 75°01'26.0"E, Chainage : 523+017**

  The subsoil stratum of borehole consists of residual soil from weathered rock from GL to 15m and mica schist till 23m. The standard penetration test values reveal that the sub-soil stratum is weathered throughout.

- **Borehole No. 122 near Chandragiri River**

  **Location : 12°28'34.8"N, 75°59'44.1"E, Chainage : 528+683.3**

The subsoil stratum of borehole consists of silty sand from GL to 6m, silty clay from 6m to 19.5m, silty sand from 19.5m to 21m, and mica schist till 30m. The standard penetration test values reveal that the sub-soil stratum is loose up to 6m, stiff from 6m to 19.5m, dense from 19.5m to 21m and weathered from 21m to 30m.

- **Borehole No. 123 near Bangarakunnu**

**Location : 12°30'44.6"N, 75°58'18.8"E, Chainage : Depot**

The subsoil stratum of borehole consists of silty sand with gravels from GL to 14.5m, reddish laterite from 14.5m to 16m and quartzite gneiss till 21m. The standard penetration test values reveal that the sub-soil stratum is loose up to 14.5m, stiff from 6m to 16m and weathered from 16m to 21m.

The geotechnical investigations carried out as above at a spacing of 5km is only preliminary investigation to obtain a profile and pattern of soils obtaining along the alignment selected. Tentative designs based soil bearing capacity, settlements, based on which preliminary designs of typical embankments, cutting, bridge, viaduct and tunnel structures have been made. These are discussed in sub sequent paragraphs. However, detailed investigation with more representatives in embankment, bridges, viaduct and tunnels will be necessary at execution stage which can be organized independently or through EPC execution contracts.

## 8.5 DESIGN OF STATION LAYOUTS:

### 8.5.1 List Of Proposed Stations And Maintenance Facilities:-

List of stations and maintenance depots with their locations and coordinates proposed for SilverLine are given in the **Table 8-6**.

**Table 8-6: List of Stations between Thiruvananthapuram and Kasaragod**

| Sl.No | Station Name | Chainage in (Km) | Inter distance in (Km) | Latitude (N) | Longitude( E) |
|---|---|---|---|---|---|
| 1 | Dead End/Begning of Track | -1.100 | 0.000 | | |
| 2 | Thiruvananthapuram | 0.000 | 1.100 | 8°30'44.94"N | 76°53'50.63"E |
| 3 | Kollam | 55.338 | 55.338 | 8°53'44.51"N | 76°39'25.56"E |
| 4 | Chengannur | 102.900 | 47.562 | 9°18'28.66"N | 76°38'26.37"E |
| 5 | Kottayam | 136.108 | 33.208 | 9°34'33.43"N | 76°22'18.74"E |
| 6 | Ernakulam | 195.329 | 59.221 | 10° 0'48.99"N | 76°22'36.56"E |
| 7 | Kochi Airport | 212.318 | 16.989 | 10° 9'21.98"N | 76°22'51.02"E |
| 8 | Thrissur | 259.117 | 46.799 | 10°30'31.32"N | 76°12'19.67"E |
| 9 | Tirur | 320.562 | 61.445 | 10°56'46.40"N | 75°54'08.66"E |

| Sl.No | Station Name | Chainage in (Km) | Inter distance in (Km) | Latitude (N) | Longitude( E) |
|---|---|---|---|---|---|
| 10 | Kozhikode | 357.868 | 37.306 | 11°14'49.70"N | 75°46'46.89"E |
| 11 | Kannur | 446.095 | 88.227 | 11°52'19.04"N | 75°22'08.96"E |
| 12 | Kasaragod | 529.450 | 83.355 | 12°29'27.51"N | 74°59'13.30"E |
| 13 | Kasaragod Depot Entry chainage(End Of Main Line) | 531.085 | 1.635 | | |
| 14 | **Total Length Start to End (Km)** | | **532.185** | | |
| 15 | **Total Length Thiruvananthapuram station Center to Kasaragod station Center** | | **529.450** | | |
| **Depot Locations** | | | | | |
| 1 | Kollam | 55.338 | 0.000 | 8°53'03.23"N | 76°38'53.47"E |
| 2 | Kasaragod | 530.953 | 475.615 | 12°30'45.59"N | 74°58'21.03"E |
| **RORO Loding/Unloading Points** | | | | | |
| 1 | Thiruvananthapuram RORO(At Kazhakkoottam) | 8.019 | 0.000 | 8°34'27.49"N | 76°51'53.64"E |
| 2 | Kollam( Attached to station) | 55.338 | 47.319 | 8°53'44.51"N | 76°39'25.56"E |
| 3 | Ernakulam RORO (At Pazhanganad) | 199.168 | 143.830 | 10° 2'42.63"N | 76°23'25.42"E |
| 4 | Thrissur RORO(At Muriyad) | 241.160 | 41.992 | 10°22'2.96"N | 76°15'00.27"E |
| 5 | Kasargod RORO (At Kasaragod Depot) | 531.950 | 290.790 | 12°30'33.22"N | 74°58'28.92"E |
| **Independent RORO Without Loading/Unloading Points** | | | | | |
| 1 | Kozhikode RORO (At West Hill) | 362.471 | 0.000 | 11°17'9.55"N | 75°45'52.78"E |
| 2 | Kannur RORO(Near Kannur) | 447.459 | 84.988 | 11°53'1.25"N | 75°21'45.63"E |
| **Engineering Maintanace Depot** | | | | | |
| 1 | Kollam(attached to station) | 55.338 | 0.000 | 8°53'44.51"N | 76°39'25.56"E |
| 2 | Thrissur RORO (At Muriyad) | 241.160 | 185.822 | 10°22'2.96"N | 76°15'00.27"E |
| 3 | Kannur RORO(Near Kannur) | 447.459 | 206.299 | 11°53'1.25"N | 75°21'45.63"E |
| **OHE Maintenance Depot** | | | | | |
| 1 | Kollam | 55.338 | 0.000 | 8°53'44.51"N | 76°39'25.56"E |
| 2 | Ernakulam RORO (At Pazhanganad) | 199.168 | 143.830 | 10° 2'42.63"N | 76°23'25.42"E |

| Sl.No | Station Name | Chainage in (Km) | Inter distance in (Km) | Latitude (N) | Longitude( E) |
|---|---|---|---|---|---|
| 3 | Tirur | 320.562 | 121.394 | 10°56'46.40"N | 75°54'08.66"E |
| 4 | Kannur RORO(Near Kannur) | 447.459 | 126.897 | 11°53'1.25"N | 75°21'45.63"E |
| **Ballast Depot Location** | | | | | |
| 1 | Kollam (Attached to station) | 55.338 | 0.000 | 8°53'44.51"N | 76°39'25.56"E |
| 2 | Kottayam( Attached to station) | 136.108 | 80.770 | 9°34'33.43"N | 76°32'18.74"E |
| 3 | Thrissur RORO (At Muriyad) | 241.160 | 105.052 | 10°22'2.96"N | 76°15'00.27"E |
| 4 | Kozhikode RORO (At West Hill) | 362.471 | 121.311 | 11°17'9.55"N | 75°45'52.78"E |
| **Brake Down Special Sidings** | | | | | |
| 1 | Kollam Depot | 55.338 | 0.000 | 8°53'03.23"N | 76°38'53.47"E |
| 2 | Kasaragod Depot | 530.953 | 475.615 | 12°30'45.59"N | 74°58'21.03"E |
| **RRV Siding Locations** | | | | | |
| 1 | Kollam Depot | 55.338 | 0.000 | 8°53'03.23"N | 76°38'53.47"E |
| 2 | Thrissur RORO( At Muriyad) | 241.160 | 185.822 | 10°22'2.96"N | 76°15'00.27"E |
| 3 | Kasaragod Depot | 530.953 | 289.803 | 12°30'45.59"N | 74°58'21.03"E |

## 8.6 BASIC STATION LAYOUTS AND DETAILS

### 8.6.1 Roll Diagram of the Corridor :-

A Roll diagram developed for the selected alignment showing station facilities such as centre line of stations, platforms, sidings, RORO loop and loading lines, service facilities, loop lines, stabling lines and Maintenance Depots of SilverLine is shown in figure below. This includes immediate and future proposals. However, segregated immediate and future proposals are given in table 8.7 subsequently. All these proposals are tentative and need a review at the time of execution. Roll diagram layouts and individual station yard layouts shown in **Figure 8-4 to 8-21** shows overall planning for land assessment and long term planning only.

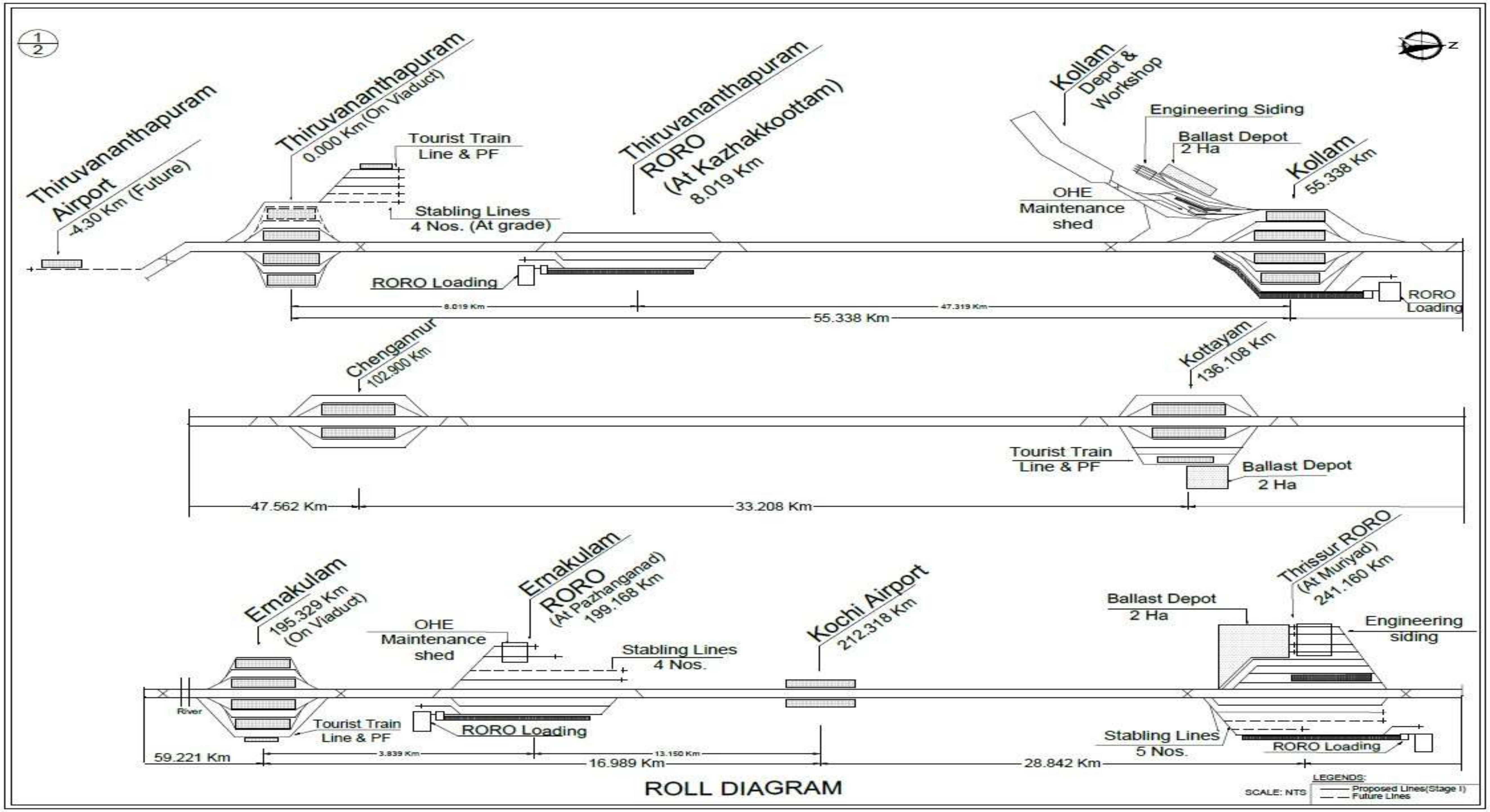



Figure 8-2: Roll Diagram Of SilverLine Project Between Thiruvananthapuram To Thrissur.

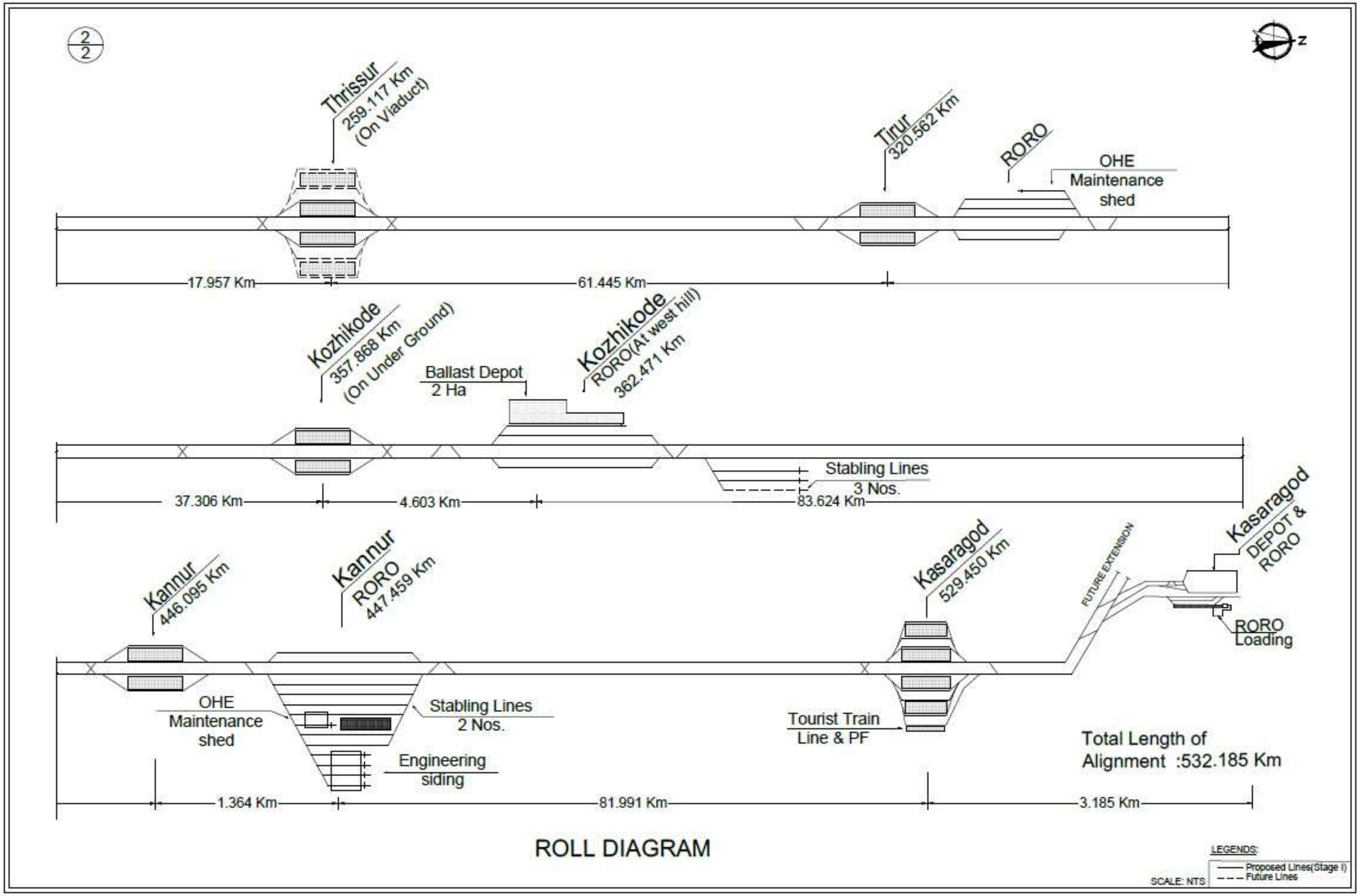



**Figure 8-3: Roll Diagram Of SilverLine Project Between Thrissur To Kasaragod**

### 8.6.2 Station Facilities Planned:-

Table below shows the proposed facilities station wise.

**Table 8-7: Details Of Structures Planned In Stations**

| Sl No | Name of Stations | Chainage In M | Details of Yard Facilities Planned | Details of Platforms Planned | Remarks |
|---|---|---|---|---|---|
| 1 | Thiruvananthapuram (On Viaduct) | 0 | 2 Nos Passenger loops with 80 kmph speed potential 609 m CSL | 3 Nos Island Platforms 410m long & 11.32 m wide | Terminal Station for passenger trains reception, despatching and stabling. |
| | | | 2 Nos Passenger loops with 45 kmph speed potential 534 m CSL | 1 No Island Platforms 410m long &11.32 m wide(For future) | On 'A' Line side one platform and two passeger loops (For future) |
| | | | 2 Nos Passenger loops with 45 kmph speed potential 534 m CSL( For future) | 1 No tourist siding platform 5.0m wide and 350m long | |
| | | | 2 Nos Stabling lines 440 m CSL(At grade) | | |
| | | | 2 Nos Stabling lines 440 m CSL at grade(For future). | | |
| | | | 1 No Tourist siding of 388 m CSL(At grade) | | |
| 2 | Thiruvanathapuram RORO (At Kazhakkoottam) | 8019 | 2 Nos RORO Loops 700 m CSL | 1No Loading Platform 866 m CSL & 10 m wide | Terminal RORO station for reception,loading,stabling and despatching. |
| | | | 1 No RORO Loading Line 800 m CSL | | |
| | | | 1 No RORO Shunting Neck 100m CSL | | |
| 3 | Kollam | 55338 | 3 Nos Passenger loops with 80 kmph speed potential of CSL 597 m , 597m & 576 m CSL | 3 Nos Island Platforms 410 m long & 11.32 m wide | Passenger Intermediate Station |
| | | | 1 No Passenger loop with 45 kmph speed potential 576 m CSL | 1No Island Platform 400 m long 11.32 m wide. | Passenger trains reception and despatching from main line to main line and empty rakes from and to depot and OHE &Engineering maintenace depot. |
| | | | 2 Nos Passenger cum RORO Loop with 45 kmph speed potential,802 m and 717 m CSL | 1 RORO loading platform 875 m long & 10 m wide | |
| | | | 1 No RORO Loading Line 800m CSL | 1 Rail platform 230 m long & 5 m wide | |
| | | | 2 Nos OHE Maintenance lines 342 m & 70m CSL | | |
| | | | 1 No Storage Track 311 m CSL | | |
| | | | 1 No Engine Run Round Track 248 m CSL | | |
| | | | 2 Nos Railway maintenance Car lines with Shed 171m & 211m CSL | | |
| | | | 2 Nos Confirmation Tracks with Shed 90 m CSL | | |
| | | | 1 No Ballast Lay Bye 436 m CSL collection area 2.00 Ha | | |
| 4 | Kollam Depot | 55338 | IBL 4 Nos 420 m CSL | IBL- 2 Nos Platforms 400 m long 3.0 m wide | Stabling Rakes Reception Maintenance and despatching after Maintenance,Work Shop,Inspection baysAnd Test track facilities. |
| | | | IBL 1 Nos 420 m CSL (For future) | | |
| | | | SBL 11 Nos 430 CSL | SBL- 6 Nos Platforms 410 m long 1.1 m wide | |
| | | | SBL 1 No 430 CSL (For future) | SBL- 1 No Platform 410 m long 1.1 m wide (For future) | |
| | | | RORO Stabling lines 2 Nos 800m CSL | | |
| | | | Workshop lines 6 Nos 410 m CSL 435 m | | |
| | | | Pit Wheel line 410 m (CSL 537 m) | | |
| | | | Heavy cleaning 410 m (CSL514 m) | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | Paint Booth line 1 No 410 m (CSL 432 m) | | |
| | | | Unloading Bay line 432 m CSL | | |
| | | | 1 No P Way Siding CSL 445 m | | |
| | | | 1 No BD Special line CSL 443 m | | |
| | | | 1 No ARME line 379 m | | |
| | | | 1 No Tourist Siding 320 m | | |
| | | | 1 No RRV siding 64 m CSL with shed | | |
| | | | 1 No Test Track 1821.5 M Length | | |
| | | | | | |
| 5 | Chengannur | 102900 | 2 Nos Passenger loops with 80 kmph speed potential 556 m CSL | 2 Nos Island Platforms 410 m long & 11.32m wide | Passenger Intermediate Station |
| | | | 2 Nos RORO loops with speed potential 45 Kmph 776m m CSL | | Reception and despatching |
| | | | | | |
| 6 | Kottayam | 136108 | 2 Nos Passenger loops with 80 kmph speed potential 556 m CSL | 2 Nos Island Platforms 410 m long & 11.32 m wide | Passenger Intermediate Station |
| | | | 2 Nos RORO loops with 45 Kmph speed potential 779 m & 700 m CSL | 1 No tourist siding platform 5m wide and 350m long | Reception and despatching |
| | | | 1 No Tourist siding of 620 m CSL | | |
| | | | 1 No Ballast Laybye of 620 M CSL with collection area 2.0Ha | | |
| | | | | | |
| 7 | Ernakulam (On Viaduct) | 195329 | 2 Nos Passenger loops with 80 kmph speed potential 609 m CSL | 4 Nos Island Platforms 410 m long & 11.32 m wide | Passenger Intermediate Station |
| | | | 4 Nos Passenger loops with 45 kmph speed potential 534 m CSL | 1 No tourist siding platform 5m wide and 350m long | Reception and despatching |
| | | | 1 No Tourist siding of 901 m CSL | | |
| | | | | | |
| 8 | Ernakulam RORO (At Pazhanganadu) | 199168 | 2 Nos Stabling lines 440 m CSL | 1 No RORO Loading Platform 872 m long & 10 m wide | RORO intermediate station |
| | | | 2 Nos Stabling lines 440 m CSL | | RORO reception and despatch ,OHE Maintenance and Stabling rakes reception and despatch. |
| | | | 1No RORO Loop 700 m CSL | | |
| | | | 1 No RORO Loading Line 800 m CSL | | |
| | | | 1 No RORO Shunting Neck 100 m CSL | | |
| | | | 2 Nos OHE Maintenance Line with Shed 300 m & 100m CSL | | |
| | | | | | |
| 9 | Kochi Airport | 212318 | No loops | 2 Nos of Single-sided Platform 410m Long & 8m wide | Passenger Intermediate Station |
| | | | | | Reception and despatching |
| | | | | | |
| 10 | Thrissur RORO (At Muriyad) | 241160 | 2 Nos RORO Loops 700 m & 807 m CSL | 1 No RORO Loading platform 851 m long & 10 m wide | RORO Intermediate station |
| | | | 2 Nos Stabling lines 440m CSL | 1 No Rail platform 230 m long & 5 m wide | RORO recetion and despatch ,Engineering Maintenance shed and Stabling rakes reception and despatch. |
| | | | 3 Nos Stabling lines 440m CSL(For future) | | |
| | | | 1 No Storage Track 523 m CSL | | |
| | | | 1 No Engine Run Round track 448 m CSL | | |
| | | | 2 Nos Railway Maintenance Cars lines with Shed 188m CSL | | |
| | | | 2 Nos Confirmation tracks with Shed 107m CSL | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | 1 No Ballast Lay Bye 622 m CSL with collection area 2.0 Ha | | |
| | | | RRV siding 66.37 m with shed | | |
| | | | | | |
| 11 | Thrissur (On Viaduct) | 259117 | 2 Nos Passenger loops with 80 kmph speed potential 609 m CSL | 2 Nos Island Platforms 410 m long 11.32 m wide | Passenger Intermediate Station |
| | | | 4 Nos Passenger loops with 45 kmph speed potential 534 m CSL (For future) | 2 Nos Island Platforms 410 m long 11.32 m wide ( For future) | Reception and despatching |
| | | | | | |
| 12 | Tirur | 320562 | 2 Nos Passenger loops with 80 kmph speed potential 556 m CSL | 2 Nos Island Platforms 410 m long & 11.32 m wide | Passenger Intermediate Station |
| | | | 2 Nos RORO Loops 700 m CSL at Separate place adjacent to Main Station | | Reception and despatching |
| | | | 2 Nos OHE Maintenance Loops 649 m & 70 m CSL at Separate place adjacent to Main Station | | |
| | | | | | |
| 13 | Kozhikode (On Under Ground) | 357868 | 2 Nos Passenger loops with 80 kmph speed potential 556 m CSL | 2 Nos Island Platforms 410m long &11.32 m wide | Passsenger Intermediate Station reception and despatching |
| | | | | | |
| 14 | Kozhikode RORO (At West Hill) | 362471 | 2 Nos RORO Loops 700 m & 764 m CSL | Nil | RORO Intermediate station & Ballast Depot |
| | | | 2 Nos Stabling lines 440 m CSL | | RORO Reception and despatching,Stabling rakes reception and despatchinh,and Ballast Depot. |
| | | | 1 No Stabling line 440 m CSL(For future) | | |
| | | | 1 No Ballast lay bye 610 m CSL collection area 2.00 Ha | | |
| | | | | | |
| 15 | Kannur | 446095 | 2 Nos Passenger loops with 80 kmph speed potential 556 m CSL | 2 Nos Island Platforms 410 m long & 11.32 m wide | Passenger Intermediate Station reception and despatching |
| | | | | | |
| 16 | Kannur RORO (At Nearer To Kannur Station) | 447459 | 2 Nos RORO loops with speed potential 45 Kmph 728 m & 624 m CSL | 1 No Rail platform 230 m long & 5 m wide | RORO intermediate station |
| | | | 2 Nos OHE Maintenance lines 592 m & 552 m CSL respectively | | RORO reception and despatching,OHE and Engineering Maintenance sheds &Stabling rakes reception and despatching |
| | | | 2 Nos Stabling lines 440 m CSL | | |
| | | | 1 No Storage Track 442 m CSL | | |
| | | | 1 No Engine Run Round track 391 m CSL | | |
| | | | 2 Nos Engineering Maintenance lines with Shed 196 m & 196 m CSL | | |
| | | | 2 Nos Confirmation tracks with Shed 71 m CSL | | |
| | | | | | |
| 17 | Kasaragod | 529450 | 2 Nos Passenger loops with 80 kmph speed potential 609 m CSL | 4 Nos Island Platforms 410m long 11.32m wide | PassengerTerminal station |
| | | | 4 Nos Passenger loops with 80 kmph speed potential 534 m CSL | 1 No tourist siding platform 5m wide and 350m long | Reception & despatching from Main lines as well as Depot. |
| | | | 1 No Tourist siding of 455 m CSL | | |
| | | | | | |
| 18 | Kasaragod RORO | 531950 | 2 Nos RORO loops 700 m CSL | 1 No RORO Loading Platform 868 m long & 10m wide | RORO terminal station |
| | | | 1 No RORO Loading line 800 m CSL | | Terminal RORO station for reception,loading,stabling and despatching. |
| | | | 1 NoShunting Neck 50 m CSL | | |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | IBL - 2 Nos CSL511 m (2 Nos are Future) | IBL- 1 No Platforms 400 mm long & 3 m wide | Terminal Maintenance Depot |
| 19 | Kasaragod Depot | 530953 | IBL - 2 Nos CSL511 m (For future) | IBL- 1 No Platforms 400 mm long & 3 m wide (For future) | Stabling rakes reception and despatching after maintenance Inspection Bays and Work shop and test track facilities |
| | | | SBL- 6 Nos 430 CSL | SBL- 3 Nos Platforms 400 mm long & 1.1 m wide | |
| | | | SBL- 9 Nos 430 CSL(For future) | SBL- 4 Nos Platforms 400 mm long & 1.1 m wide | |
| | | | 1 No P Way siding CSL 229 m | | |
| | | | 1 No BD Special CSL 339 m | | |
| | | | 1 No ARME line 263 m | | |
| | | | 1 No Tourist Train Line 340 m CSL | | |
| | | | RRV siding 156 m with shed | | |
| | | | 1 No Test Track 1435.0 m CSL | | |
| | | | | | |

*Note: All initial and future phases requirements are included in the cost estimate. All future requirements will be reviewed as traffic grows and facilities justify.*

## 8.6.3 Detailed Layouts of Stations & Others :-

### 8.6.3.1 The detailed layouts

The detailed layouts for various stations and other features in the project  are shown in Figure below:

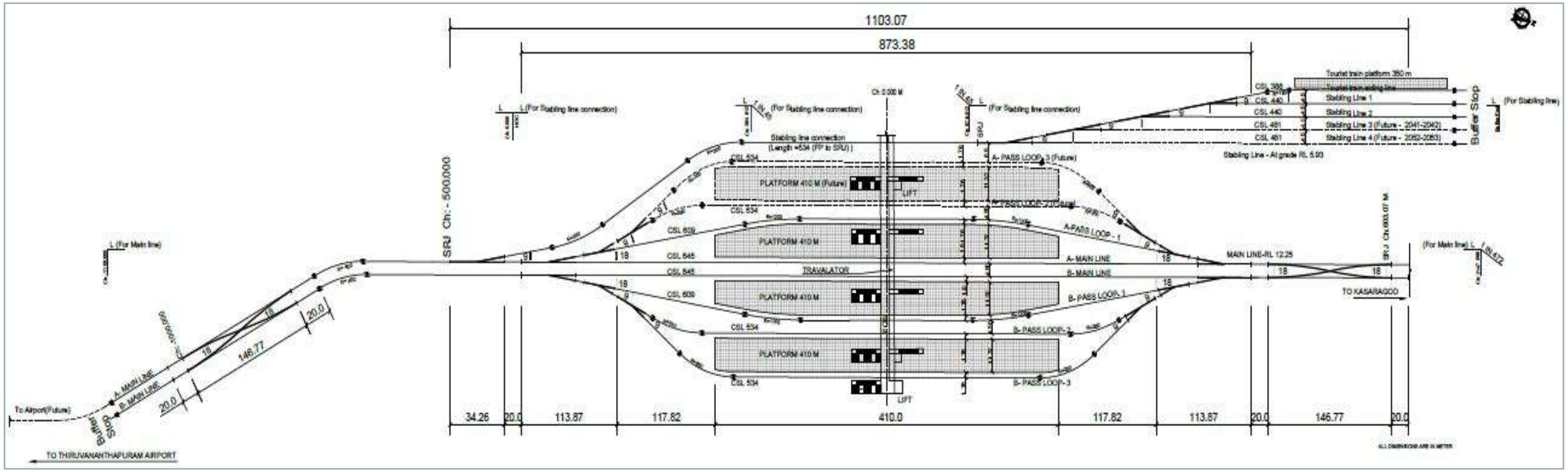



**Figure 8-4: Thiruvananthapuram Station (On Viaduct)**

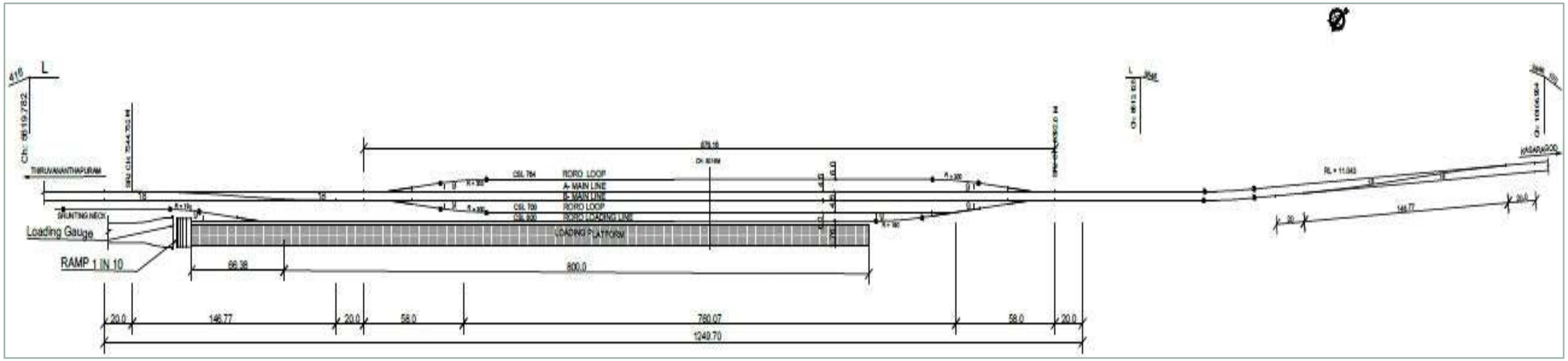



Figure 8-5: Thiruvananthapuram RORO Station (At-Grade)

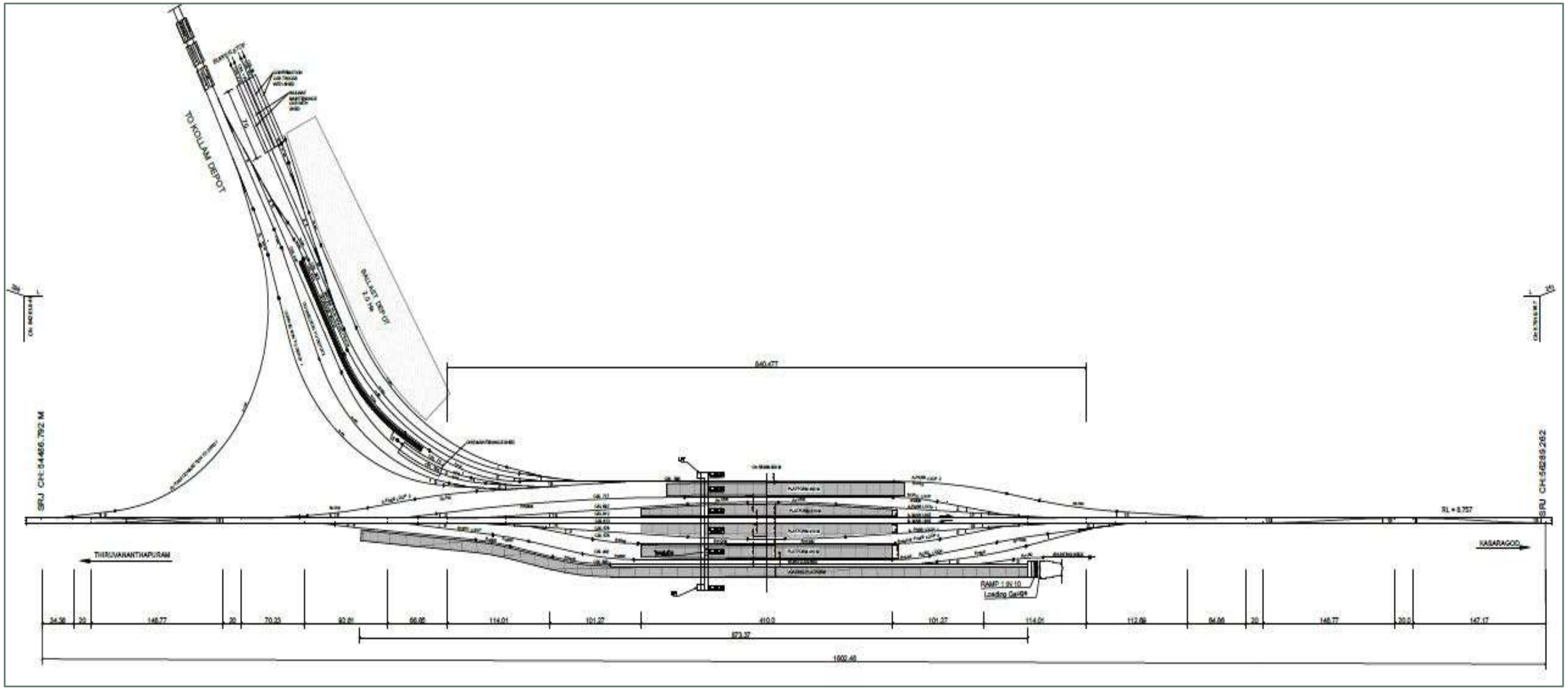



Figure 8-6: Kollam Station (At-Grade)

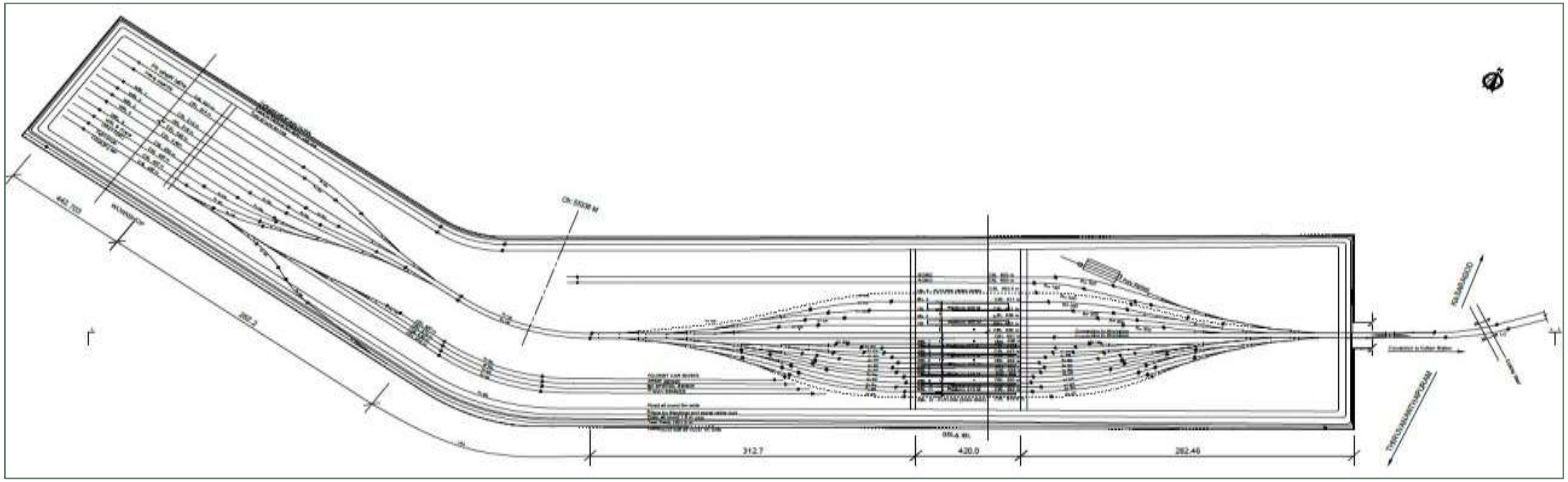



Figure 8-7: Kollam Depot (At-Grade)

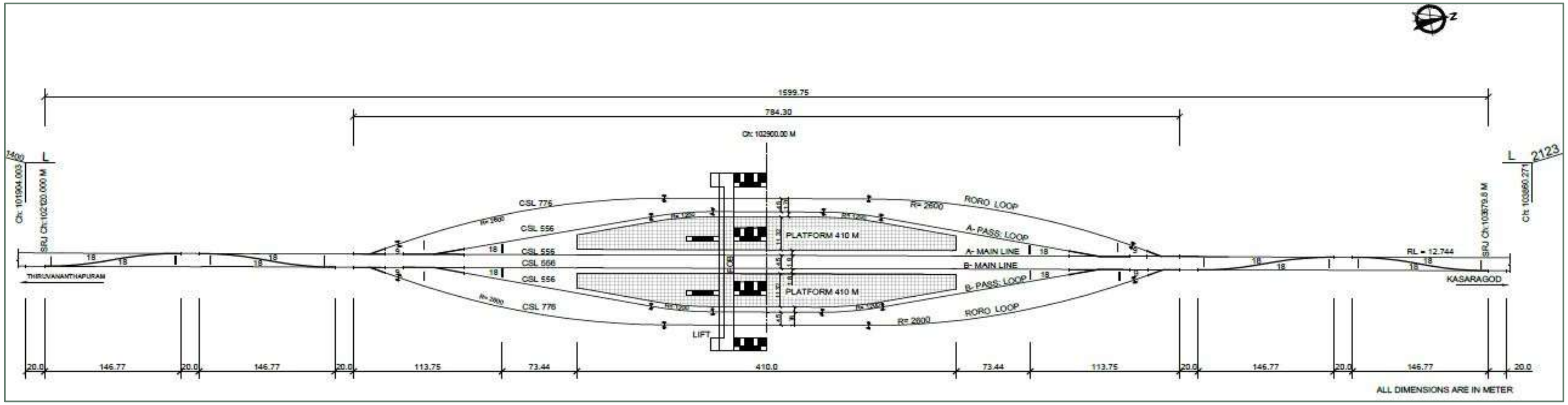



**Figure 8-8: Chengannur Station (At-Grade)**

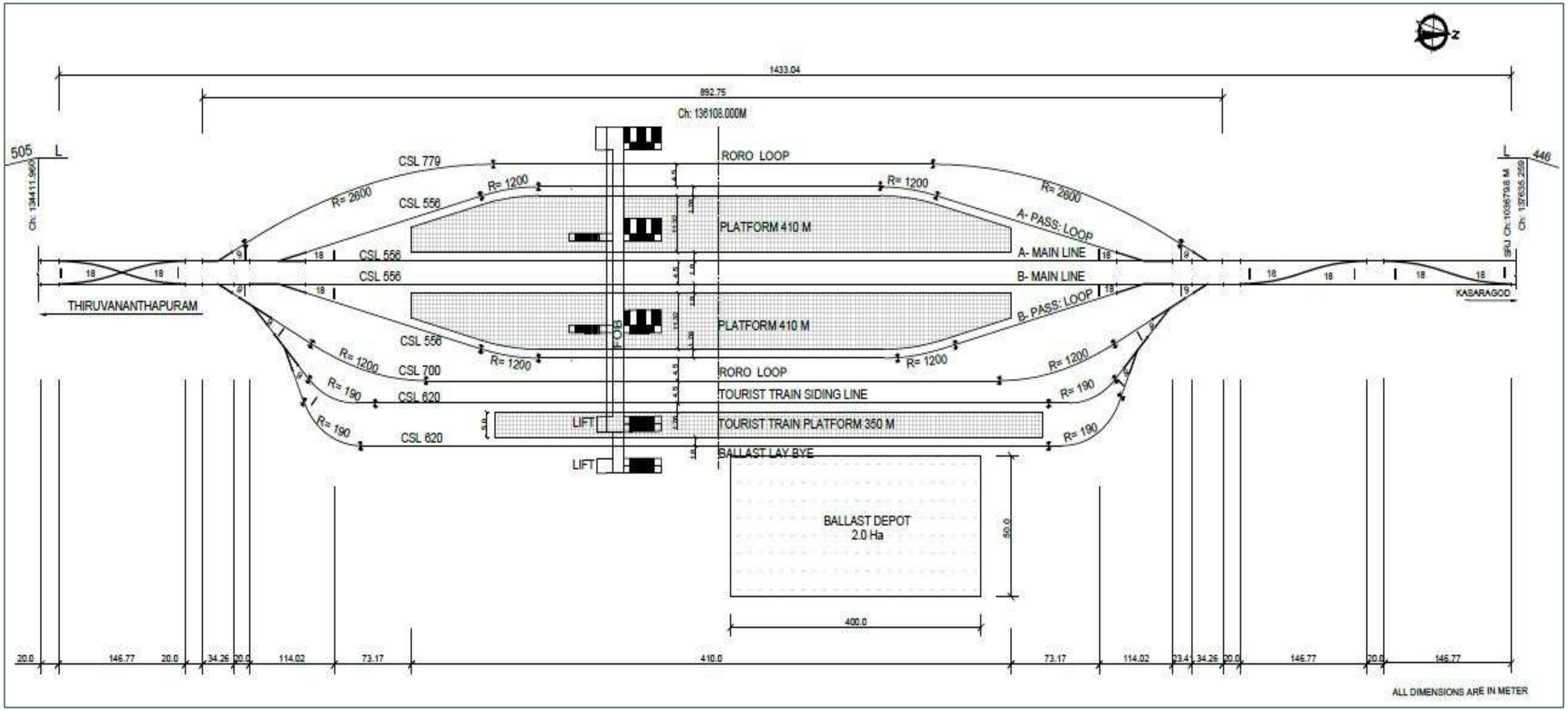



**Figure 8-9: Kottayam Station (At-Grade)**

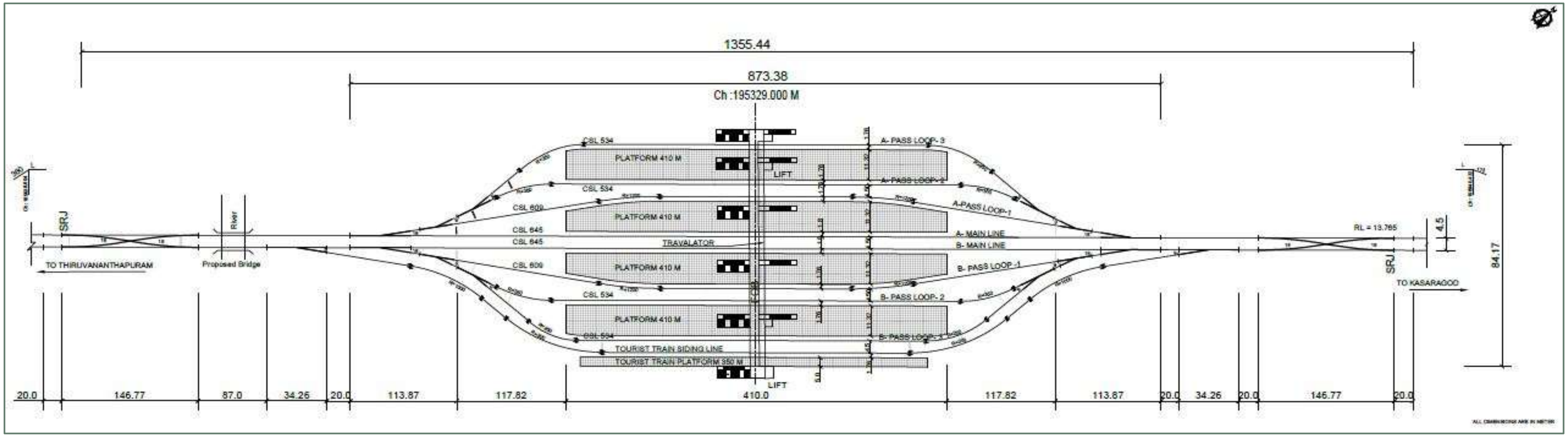



**Figure 8-10: Ernakulam Station (On Viaduct)**

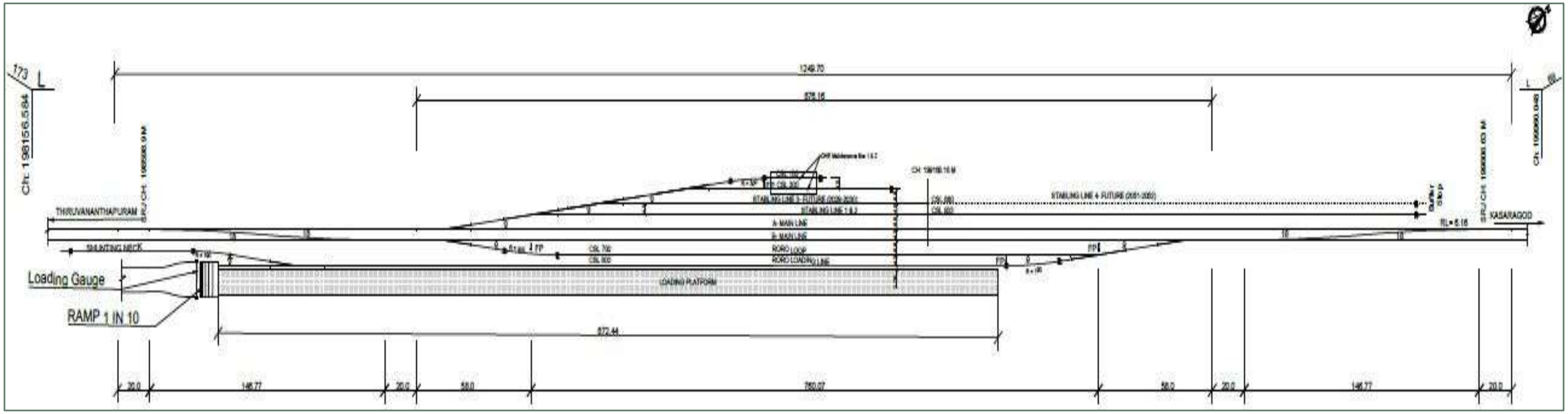



**Figure 8-11: Ernakulam RORO Station (At-Grade)**

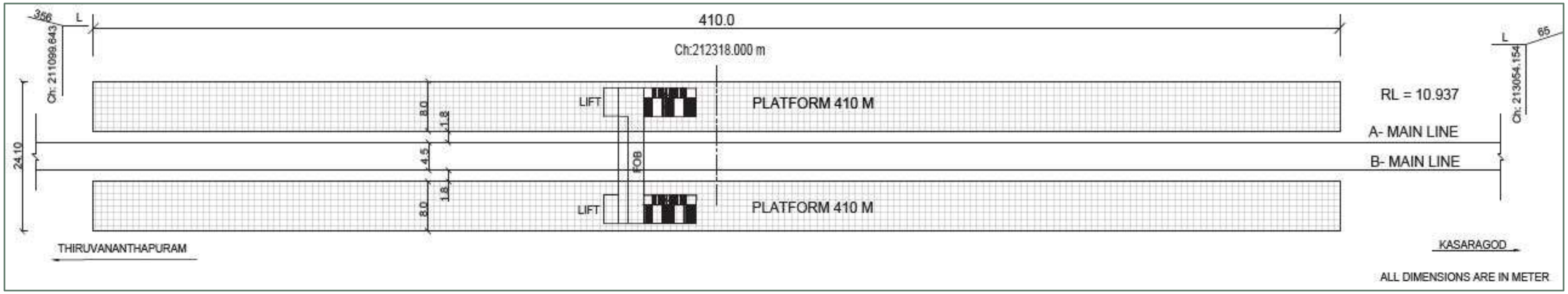



**Figure 8-12: Kochi Airport Station (At-Grade)**

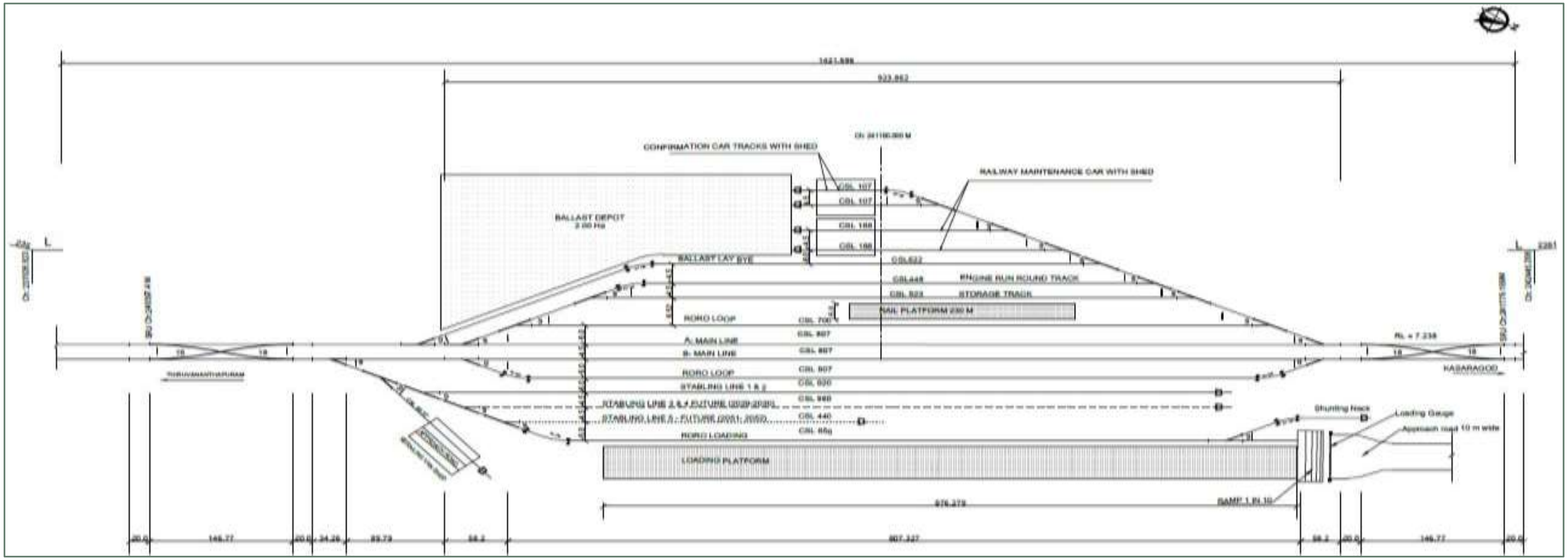



Figure 8-13: Thrissur RORO Station (At-Grade)

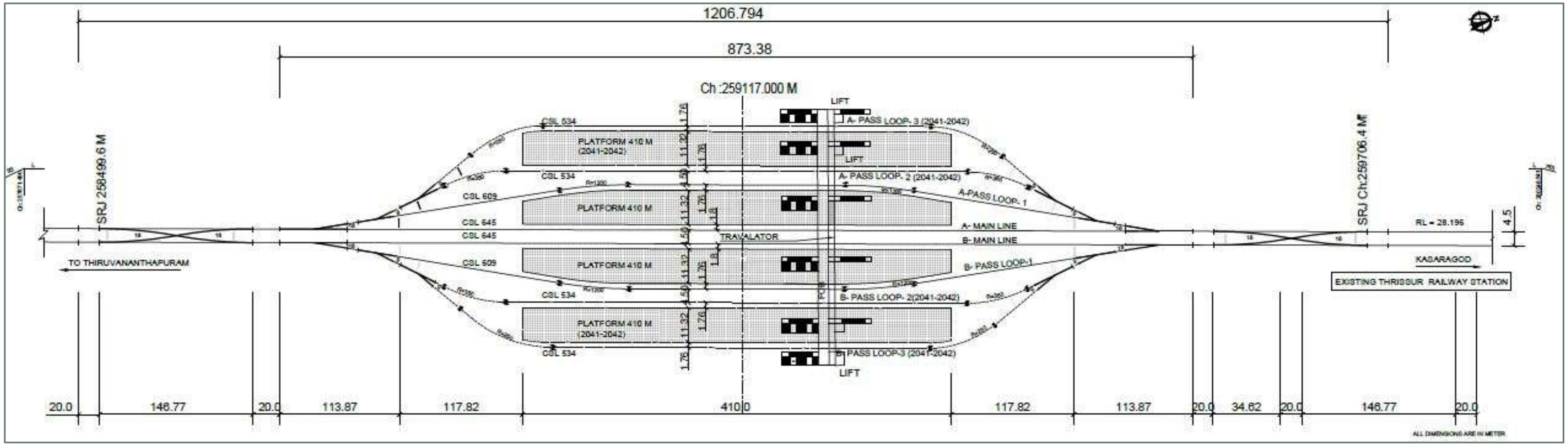



Figure 8-14: Thrissur Station (On Viaduct)

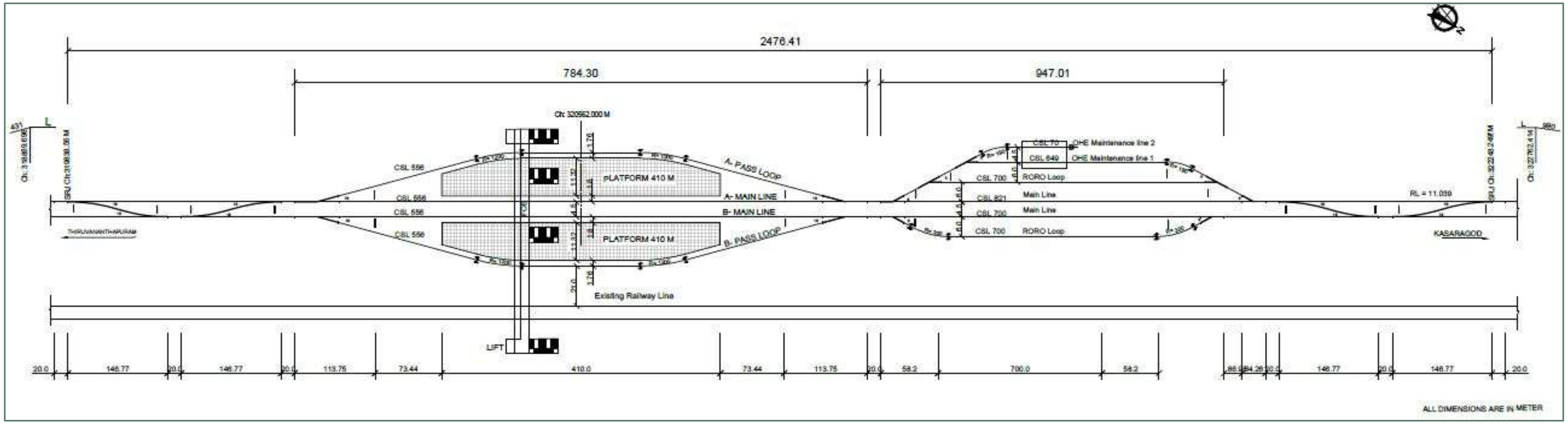



Figure 8-15: Tirur Station (At-Grade)

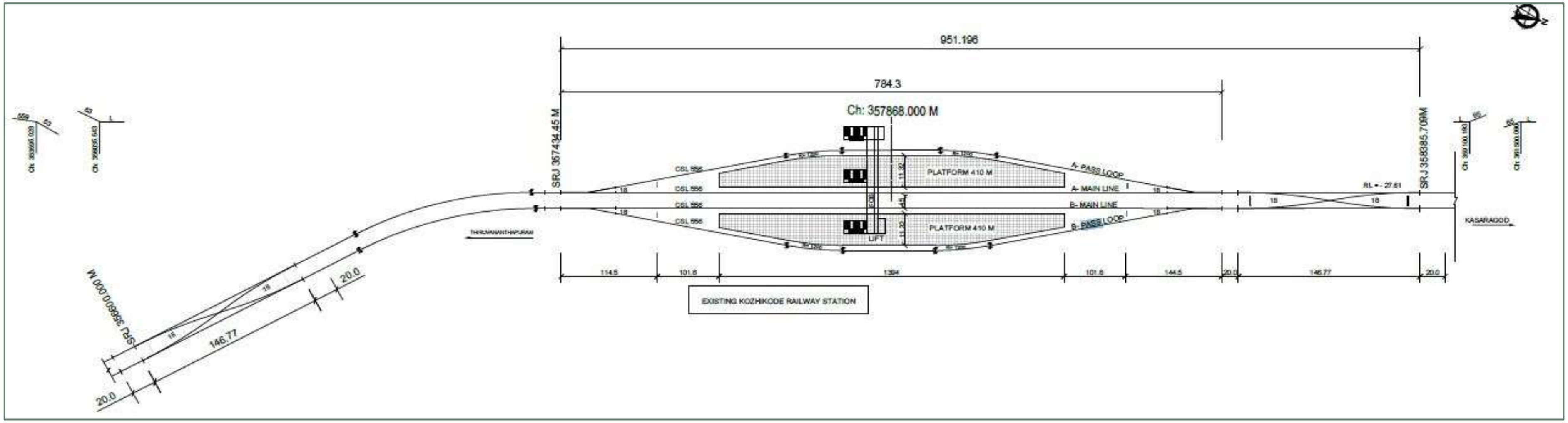



Figure 8-16: Kozhikode Station (Underground)

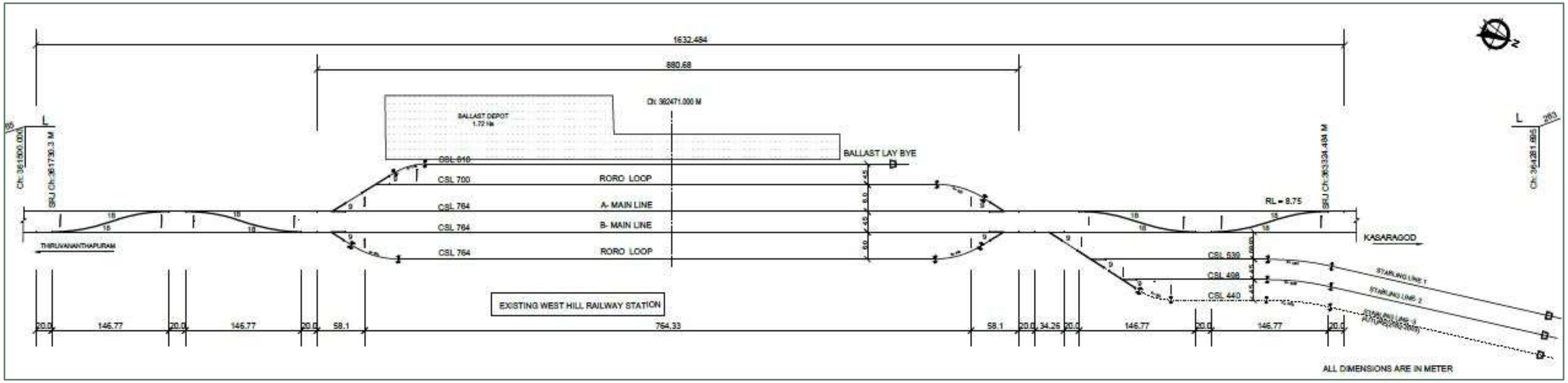



**Figure 8-17: Kozhikode RORO Station (At-Grade)**

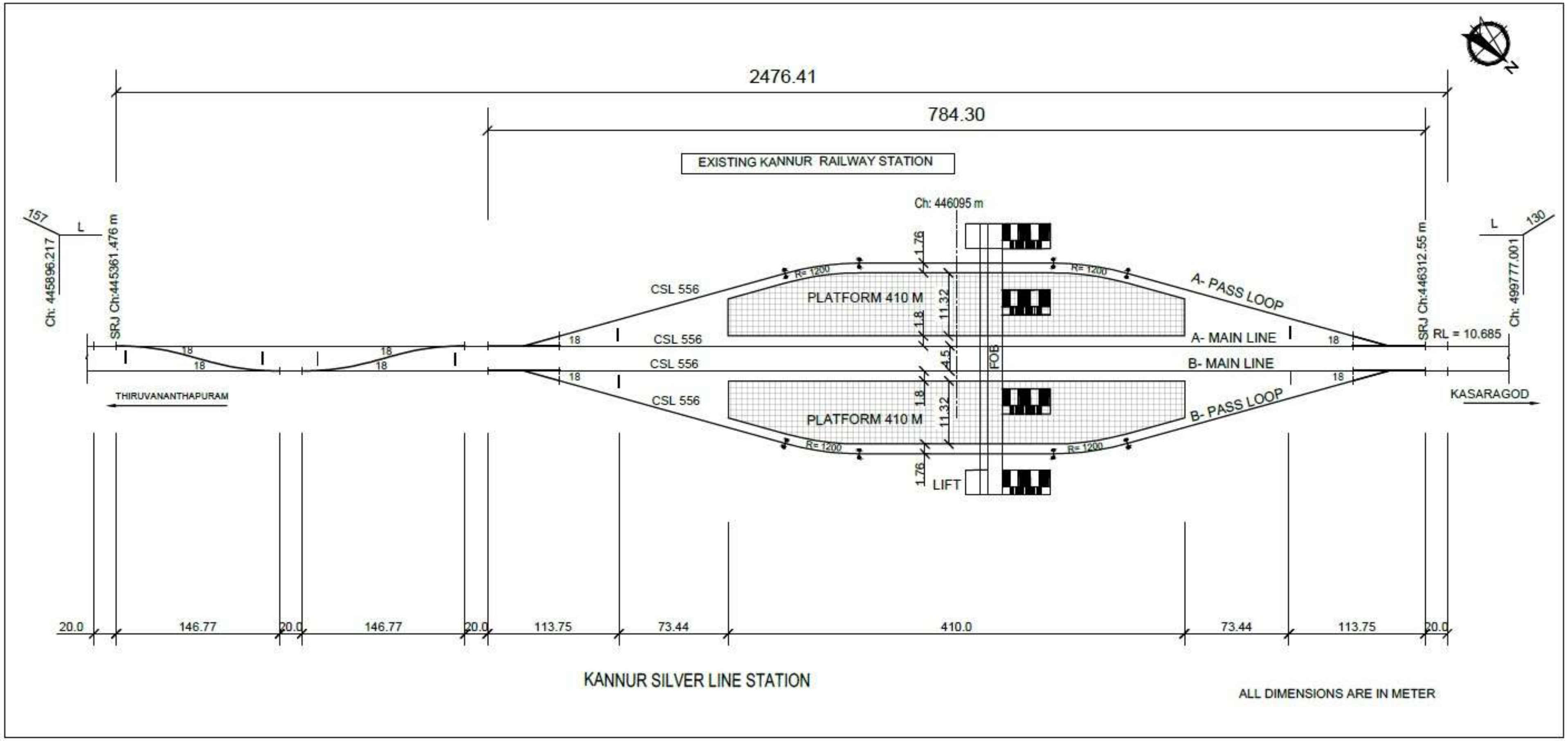



**Figure 8-18: Kannur Station (At-Grade)**

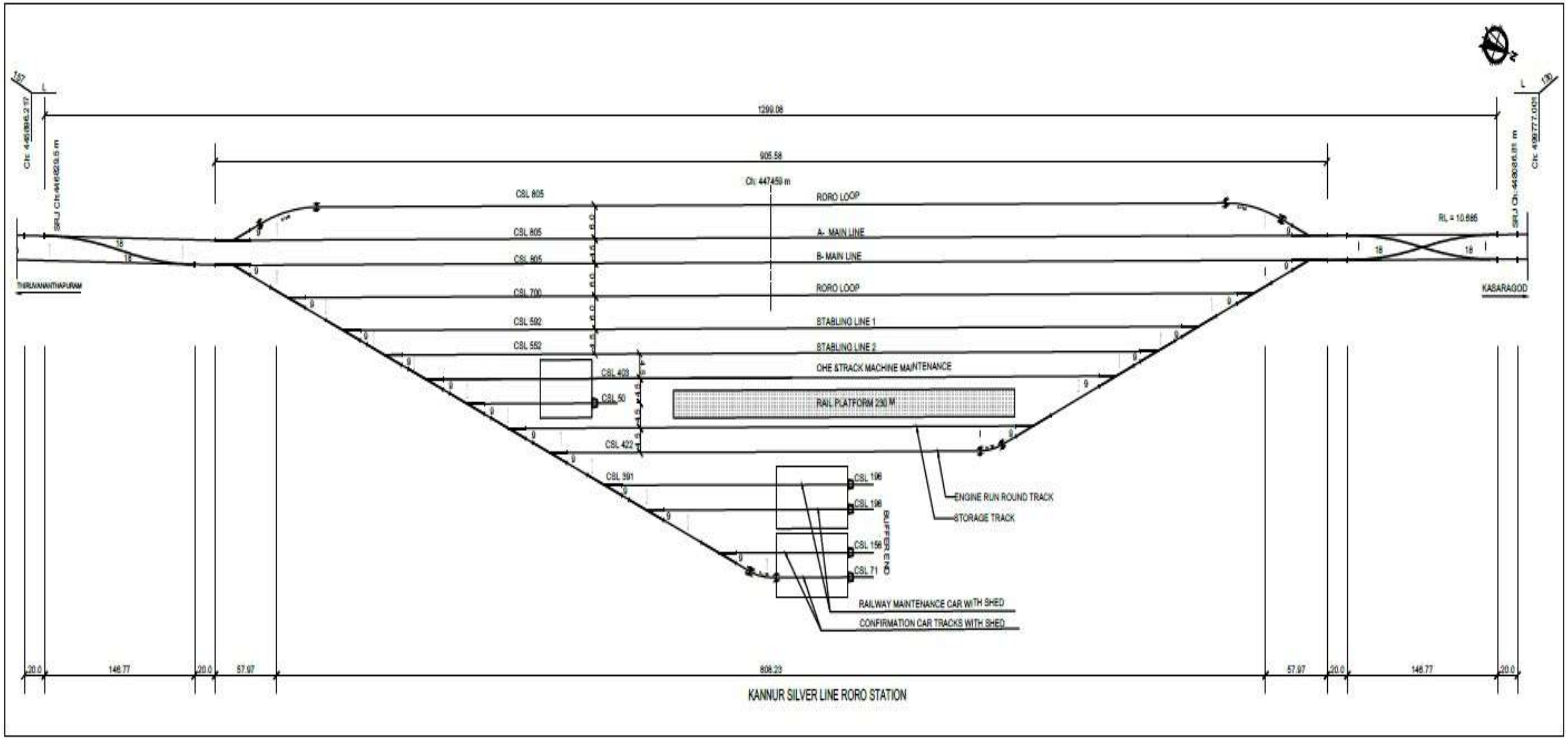



**Figure 8-19: Kannur RORO Station (At-Grade)**

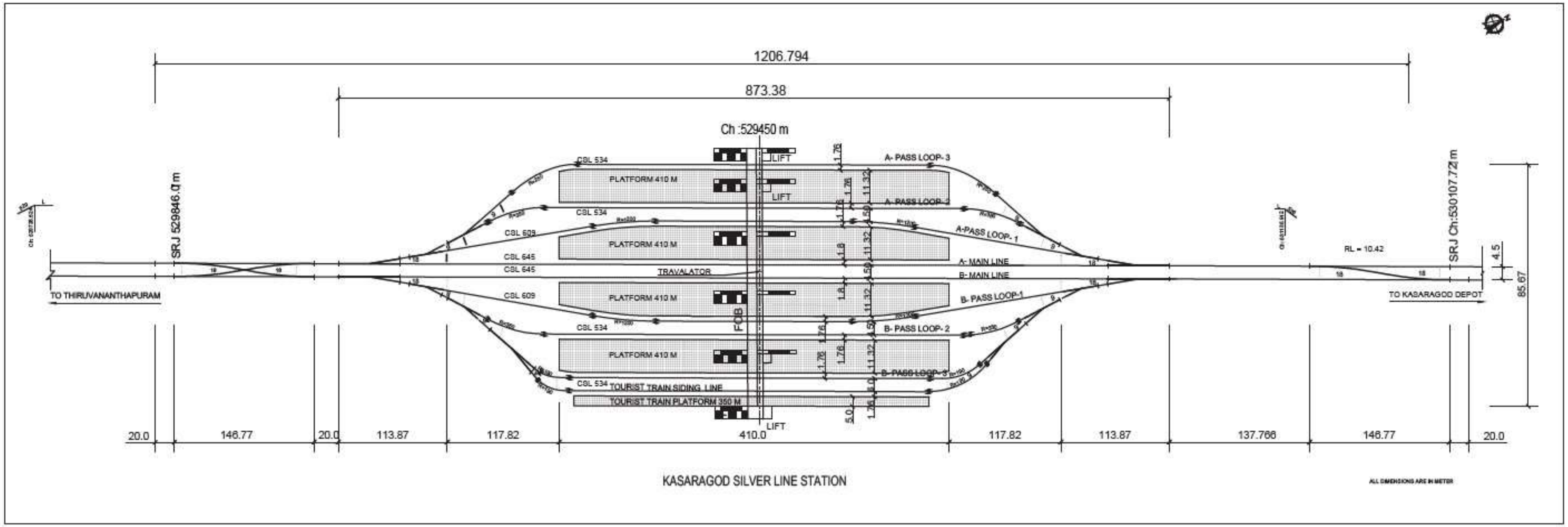



Figure 8-20: Kasaragod Station (At-Grade)

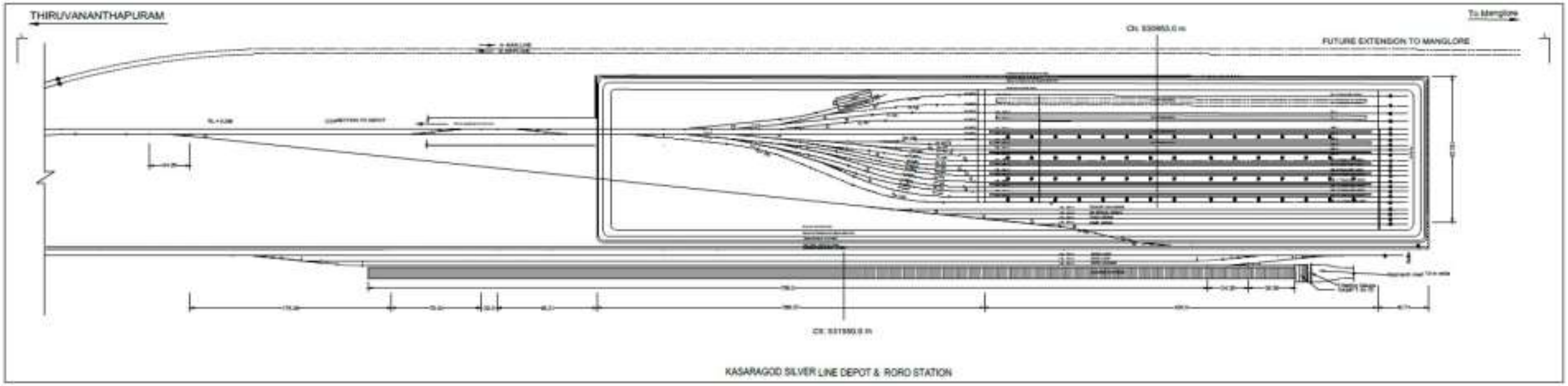



**Figure 8-21: Kasaragod Depot & RORO Station (At-Grade)**

## 8.6.4 Sumamry of Track Length

Based on the above finalised drawings, the Summary of Track Length are shown in **Table below.**

**Table 8-8: Summary of Track Length**

| Sl No | Name of Stations | Service Area | Running lines | | | | Non Running lines | | | | Buffer Stops | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Name of Loop | Length in m | Extra length between Turnouts | CSL | Name of Loop | Length in m | Extra length between Turnouts | CSL | ML | N RL |
| 1 | Main Line DL | Thiruvanthapuram Station centre to Kasaragod Station centre | | 529450 | | | | | | | 0 | 0 |
| | | Kasaragod Station Centre to entry Point of KSD depot | | 1635.0 | | | | | | | 2 | 0 |
| | | Thiruvanthapuram Station centre to End | | 1100.0 | | | | | | | 2 | 0 |
| | **Total** | | | **532185** | | | | | | | **4** | **0** |
| | | | | | | | | | | | | |
| **Summary Of Extra BLT Track BetweenThiruvananthapuram to Kasaragod** | | | | | | | | | | | | |
| 1 | Thiruvananthapuram (On Viaduct) | Station Extra Lines Other than Main line | Pass: Loop A 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass: Loop A 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop A 3 | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop B 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pass: Loop B 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop B 3 | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | Extra Length between Turnouts | | 66.0 | | | | | | | | |
| | | **Total** | | **3696.1** | | | | | | | **0** | **0** |
| 2 | Ernakulam( On Viaduct) | Station Extra Lines Other than Main line | Pass:Loop A 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass:Loop A 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop A 3 | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | | Pass:Loop B 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass:Loop B 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop B 3 | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | | | | | | Tourist car siding line (At Grade) | 901.6 | | 845.0 | 0 | 0 |
| | | Extra Length between Turnouts | | 66.0 | | | | | | | | |
| | | **Total** | | **3696.1** | | | | **901.6** | | | **0** | **0** |
| 3 | Thrissur (On Viaduct) | Station Primise | Pass:Loop A 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass:Loop A 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop A | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | | Pass:Loop B 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass:Loop B 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop B | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | Extra Length between Turnouts | | 66.0 | | | | | | | | |
| | | **Total** | | **3696.1** | | | | | | | **0** | **0** |
| 4 | Kozhikkode Main( UG) | Station primise | Pass:Loop A | 655.4 | | 556.0 | | | | | **0** | 0 |
| | | | Pass:Loop B | 655.4 | | 556.0 | | | | | **0** | 0 |
| | | Extra Length between Turnouts | | 0.0 | | | | | | | **0** | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Total** | | **1310.8** | | | | | | | **0** | 0 |
| | | **Grant total** | | **16899.1** | | | | **901.6** | | | **1** | **0** |
| | **NRL** | | | **901.6** | | | | | | | | |
| | **Grant Total** | | | **17800.6** | | | | | | | | |
| | Main line(A&B) | (separate estimate) | | **58061.0** | | | | | | | | |
| **Summary Of Extra Ballasted Track BetweenThiruvananthapuram to Kasaragod** | | | | | | | | | | | | |
| **1** | **Thiruvananthapuram At Grade** | Stabling lines( At Grade) | | | | | Stabling line A 1 (At Grade) | 430.2 | 6.5 | 440.0 | 0 | 1 |
| | | | | | | | Stabling line A 2(At Grade) | 470.7 | 6.5 | 440.0 | 0 | 1 |
| | | | | | | | Stabling line A 3 (Future)(At Grade) | 511.2 | 6.5 | 481.0 | 0 | 1 |
| | | | | | | | Stabling line A 4(Future)(At Grade) | 551.0 | | 481.0 | 0 | 1 |
| | | | | | | | Tourist car siding line (At Grade) | 430.5 | | 388.0 | 0 | 1 |
| | | Extra Length between Turnouts | | | | | | 19.5 | | | | |
| | | **Grant Total** | | | | | | **2413.2** | | | | **5** |
| 2 | Thiruvananthapuram RORO | RORO | RORO Loop A | 812.6 | 0.0 | 764.0 | | | | | | 0 |
| | | | RORO Loop B | 758.3 | 20.0 | 700.0 | | | | | | 0 |
| | | | | | | | RORO Loading B | 877.8 | | 800.0 | | 0 |
| | | | | | | | Shunting Neck | 130.9 | | 100.0 | | 1 |
| | | Extra Length between Turnouts | | 20.0 | | | | | | | | |
| | | **Total** | | **1590.9** | | | | **1008.7** | | | | **1** |
| 3 | Kollam | Station Primise & RORO | Pass:Loop A 1 | 667.3 | 10.0 | 597 | | | | | 0 | 0 |
| | | | Pass:Loop A 2 | 803.0 | | 593.0 | | | | | 0 | 0 |
| | | | RORO Loop A | 765.5 | 10.0 | 717.0 | | | | | 0 | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pass:Loop B 1 | 623.1 | 20.0 | 576.0 | | | | | 0 | 0 |
| | | | Pass:Loop B 2 | 624.6 | | 576.0 | | | | | 0 | 0 |
| | | | RORO B | 869.1 | 6.5 | 802.0 | | | | | 0 | 0 |
| | | | | | | | OHE Maintance 1 | 407.2 | 6.5 | 342.0 | 0 | 0 |
| | | | | | | | OHE Maintance 2 | 96.0 | | 50.0 | 0 | 1 |
| | | | | | | | Storage Track | 394.5 | 6.5 | 311.0 | 0 | 0 |
| | | | | | | | Engineering Run Round Track | 389.2 | | 248.0 | 0 | 0 |
| | | | | | | | Connection of Rlway Maintanence& Confirmation Car | 262.3 | | 175.5 | 0 | 0 |
| | | | | | | | Railway Maintanence car with shed 1 | 243.1 | | 211.0 | 0 | 1 |
| | | | | | | | Railway Maintanence car with shed 2 | 201.4 | 6.5 | 171.0 | 0 | 1 |
| | | | | | | | Confirmation Car with shed 1 | 130.1 | 37.6 | 90.0 | 0 | 1 |
| | | | | | | | Confirmation Car with shed 2 | 130.4 | | 90.0 | 0 | 1 |
| | | | | | | | Ballast lay Bye | 439.8 | 6.5 | 435.9 | 0 | 1 |
| | | | | | | | RORO Loading B | 835.5 | | | 0 | 0 |
| | | | | | | | Shunting Neck | 117.1 | | 86.0 | 0 | 1 |
| | | | | | | | connection RORO loading to RORO Loop | 112.2 | | 124.0 | 0 | 0 |
| | | | | | | | Connection to Depot -1 | 630.7 | 6.5 | 388.9 | 0 | 0 |
| | | | | | | | connection to Depot - 2 | 647.6 | | 464.0 | 0 | 0 |
| | | | | | | | connection to Depot - Future | 388.9 | | 336.1 | 0 | 0 |
| | | Extra lenth between Tournouts | | 46.5 | | | | 70.1 | | | 0 | |
| | | **Total** | | **4399.2** | | | | **5496.1** | | | **0** | **7** |
| 4 | | | Test Track | 1821.5 | | | | | | | 2 | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kollam Depot | | | | | | Inspection Bay Line 4 | 652.7 | | 511.0 | 0 | 0 |
| | | | | | | | Inspection Bay Line 3 | 650.1 | 13 | 511.0 | 0 | 0 |
| | | | | | | | Inspection Bay Line 2 | 730.0 | 13 | 535.0 | 0 | 0 |
| | | | | | | | Inspection Bay Line 1 | 729.2 | 18 | 535.0 | 0 | 0 |
| | | | | | | | Inspection Bay Line 5 (Future) | 856.7 | 6.5 | 592.5 | 0 | 0 |
| | | | | | | | Stabling Bay Line 1 | 568.3 | 26 | 449.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 2 | 568.4 | | 449.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 3 | 568.5 | 13 | 447.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 4 | 569.3 | | 435.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 5 | 651.1 | 13 | 435.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 6 | 569.3 | | 434.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 7 | 734.2 | 13 | 434.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 8 | 655.9 | 13 | 430.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 9 | 658.5 | | 430.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 10 | 741.9 | 13 | 434.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 11 | 744.0 | | 434.0 | 0 | 0 |
| | | | | | | | Stabling Bay Line 12 | 668.9 | | 616.6 | 0 | 0 |
| | | | | | | | RORO 1 | 920.4 | 6.5 | 800.0 | 0 | 1 |
| | | | | | | | RORO 2 | 881.0 | 6.5 | 800.0 | 0 | 1 |
| | | | | | | | Workshop bay line 1 | 625.1 | | 514.0 | 0 | 1 |
| | | | | | | | Workshop bay line 2 | 625.4 | | 519.0 | 0 | 1 |
| | | | | | | | Workshop bay line 3 | 666.3 | | 485.0 | 0 | 1 |
| | | | | | | | Workshop bay line 4 | 626.1 | | 478.0 | 0 | 1 |
| | | | | | | | Workshop bay line 5(Future) | 546.2 | | 450.0 | 0 | 1 |
| | | | | | | | Workshop bay line 6 (Future) | 547.2 | | 435.0 | 0 | 1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Pit Wheel Lathe | 626.9 | | 537.0 | 0 | 1 |
| | | | | | | | Heavy Cleaning | 625.7 | | 514.0 | 0 | 1 |
| | | | | | | | Paint Booth | 548.8 | | 432.0 | 0 | 1 |
| | | | | | | | Un Loading Bay | 550.5 | | 432.0 | 0 | 1 |
| | | | | | | | ARME Siding | 379.4 | | 322.0 | 0 | 1 |
| | | | | | | | BD Special Siding | 433.7 | | 392.0 | 0 | 1 |
| | | | | | | | Tourist car siding | 367.1 | | 320.0 | 0 | 1 |
| | | | | | | | P Way Siding | 490.7 | | 445.0 | 0 | 1 |
| | | | | | | | Connection to Workshop 1 | 876.1 | 13 | 550.0 | 0 | 0 |
| | | | | | | | Connection to Workshop 2 | 953.0 | 6.5 | 591.0 | 0 | 0 |
| | | | | | | | ReRailing Van line | 87.0 | | | 0 | 1 |
| | | Extra Length between Turnouts | | | | | | 174.0 | | | | |
| | | **Total** | | **1821.5** | | | | **22867.8** | | | **2** | **17** |
| 5 | Chengannur | Station Primise& RORO | Pass: Loop A | 655.4 | | 556.0 | | | | | 0 | 0 |
| | | | RORO Loop A | 825.8 | | 776.0 | | | | | 0 | 0 |
| | | | Pass: Loop B | 655.4 | | 556.0 | | | | | 0 | 0 |
| | | | RORO Loop B | 825.8 | | 776.0 | | | | | 0 | 0 |
| | | **Total** | | **2962.3** | | | | | | | **0** | **0** |
| 6 | Kottayam | Station primise & RORO | Pass: Loop A | 655.4 | | 556.0 | | | | | | |
| | | | RORO Loop A | 829.3 | | 779.0 | | | | | | |
| | | | Pass: Loop B | 655.4 | | 556.0 | | | | | | |
| | | | RORO B | 744.9 | 13.0 | 700.0 | | | | | | |
| | | | | | | | Tourist Train line | 706.8 | 13 | 620.0 | 0 | 0 |
| | | | | | | | Ballast lay bye | 669.3 | | 620.0 | 0 | 0 |
| | | Extra Length between Turnouts | | 13.0 | | | | 13.0 | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Total** | | **2898.0** | | | | **1389.1** | | | | **0** |
| 7 | Ernakulam RORO | RORO | RORO Loop B | 754.0 | 20.0 | 700.0 | | | | | 0 | 0 |
| | | | | | | | Stabling line A 1 & A 2 | 964.8 | 40 | 880.0 | 0 | 1 |
| | | | | | | | Stabling line A 3 & A 4 (Future) | 924.3 | | 880.0 | 0 | 1 |
| | | | | | | | OHE Maintance A1 | 341.9 | | 300.0 | | 1 |
| | | | | | | | OHE Maintance A2 | 141.5 | | 100.0 | | 1 |
| | | | | | | | RORO Loading B | 877.8 | | 800.0 | 0 | 0 |
| | | | | | | | Shunting Neck | 130.9 | | 100.0 | 0 | 1 |
| | | Extra Length between Turnouts | | 20.0 | | | | 40.0 | | | | |
| | | **Total** | | **774.0** | | | | **3421.2** | | | | **5** |
| 8 | Kochi Airport | Station Primise | | **0.0** | **0.0** | **0.0** | | **0.0** | 0 | 0.0 | | **0** |
| 9 | Thrissur RORO | RORO, Stabling Sidings,Engineering sidings& Machine sidings | RORO Loop A | 746.9 | 40.0 | 700.0 | | | | | 0 | 0 |
| | | | RORO Loop B | 855.8 | | 807.0 | | | | | 0 | 0 |
| | | | | | | | Stabling line B1 & B2 | 950.7 | 20 | 920.0 | 0 | 1 |
| | | | | | | | Stabling line B3 & B4 (Future) | 910.2 | 6.5 | 880.0 | 0 | 1 |
| | | | | | | | Stabling Line B5 (Future) | 471.1 | 6.5 | 440.0 | 0 | 1 |
| | | | | | | | Storage Track A | 592.9 | 86.606 | 528.0 | 0 | 0 |
| | | | | | | | Engineering Run Round Track A | 552.7 | 6.5 | 488.0 | 0 | 0 |
| | | | | | | | Railway Maintanence car with shed A1 | 259.4 | 20 | 188.0 | 0 | 1 |
| | | | | | | | Railway Maintanence car with shed A2 | 218.8 | 6.5 | 188.0 | 0 | 1 |
| | | | | | | | Confirmation Car with shed A1 | 147.5 | 37.5 | 107.0 | 0 | 1 |
| | | | | | | | Confirmation Car with shed A2 | 147.8 | | 107.0 | 0 | 1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ballast lay Bye A | 688.6 | 6.5 | 622.0 | 0 | 1 |
| | | | | | | | RORO Loading B | 929.2 | | 800.0 | 0 | 0 |
| | | | | | | | ReRailing Van line B | 85.3 | | 56.0 | 0 | 1 |
| | | | | | | | Shunting Neck B | 80.9 | | 50.0 | 0 | 1 |
| | | Extra Length between Turnouts | | 40.0 | | | | 196.6 | | | | |
| | | **Total** | | **1642.8** | | | | **6231.8** | | | **0** | **10** |
| 10 | Tirur | Station Primise | Pass:Loop A | 655.4 | | 556.0 | | | | | 0 | 0 |
| | | | Pass:Loop B | 655.4 | | 556.0 | | | | | 0 | 0 |
| | | RORO | RORO Loop A | 761.4 | 40.0 | 700.0 | | | | | 0 | 0 |
| | | | RORO Loop B | 748.7 | | 700.0 | | | | | 0 | 0 |
| | | | | | | | OHE maintanence A1 | 707.6 | 20 | 649.0 | 0 | 0 |
| | | | | | | | OHE maintanence A2 | 111.9 | | 70.0 | 0 | 1 |
| | | Extra Length between Turnouts | | 40.0 | | | | 20.0 | | | | |
| | | **Total** | | **2860.8** | | | | **839.5** | | | **0** | **1** |
| 11 | Kozhikode RORO(West Hill) | RORO & Stabling Line | RORO Loop A | 758.5 | 20 | 700.0 | | | | | 0 | 0 |
| | | | RORO Loop B | 812.8 | | 764.0 | | | | | 0 | 0 |
| | | | | | | | Stabling line B 1 | 577.8 | 20 | 539.0 | 0 | 1 |
| | | | | | | | Stabling line B 2 | 537.3 | 6.5 | 498.0 | 0 | 1 |
| | | | | | | | Stabling line B 3 | 496.8 | 6.5 | 440.0 | 0 | 1 |
| | | | | | | | Ballast lay Bye | 651.8 | | 610.0 | 0 | 1 |
| | | Extra Length between Turnouts | | 20.0 | | | | 33.0 | | | | |
| | | **Total** | | **1591.2** | | | | **2296.6** | | | **0** | **4** |
| 12 | Kannur | Station Primise | Pass:Loop A | 655.4 | | 556.0 | | | | | | 0 |
| | | | Pass:Loop B | 655.4 | | 556.0 | | | | | | 0 |
| | | Extra Length between Turnouts | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Total** | | **1310.8** | | | | | | | | |
| 13 | Kannur RORO | RORO, Stabling Sidings,Engineering sidings& Machine sidings | RORO Loop A | 856.2 | | 807 | | | | | 0 | 0 |
| | | | RORO Loop B | 747.6 | 40.0 | 700 | | | | | 0 | 0 |
| | | | | | | | Stabling Line 1 | 639.66 | 40 | 592 | 0 | 0 |
| | | | | | | | Stabling Line 2 | 558.67 | 13 | 552 | 0 | 0 |
| | | | | | | | OHE Maintance 1 | 450.7 | 13 | 403.0 | 0 | 0 |
| | | | | | | | OHE Maintance 2 | 80.4 | 6.5 | 50.0 | 0 | 1 |
| | | | | | | | Storage Track | 268.9 | 73.82 | 211.0 | 0 | 0 |
| | | | | | | | Engineering Run Round Track | 228.8 | 6.5 | 171.0 | 0 | 0 |
| | | | | | | | Railway Maintanence car with shed 1 | 245.7 | 6.5 | 196.0 | 0 | 1 |
| | | | | | | | Railway Maintanence car with shed 2 | 205.2 | 6.5 | 197.0 | 0 | 1 |
| | | | | | | | Confirmation Car with shed 1 | 134.1 | 37.37 | 71.0 | 0 | 1 |
| | | | | | | | Confirmation Car with shed 2 | 134.4 | | 71.0 | 0 | 1 |
| | | Extra Length between Turnouts | | 40.0 | | | | 203.2 | | | | |
| | | **Total** | | **1643.9** | | | | **3149.5** | | | **0** | **5** |
| 14 | Ksaragod | | Pass: Loop A 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass: Loop A 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop A 3 | 581.8 | | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop B 1 | 655.9 | 20.0 | 609.0 | | | | | 0 | 0 |
| | | | Pass: Loop B 2 | 577.3 | 13.0 | 534.0 | | | | | 0 | 0 |
| | | | Pass: Loop B 3 | 541.3 | 6.5 | 534.0 | | | | | 0 | 0 |
| | | | | | | | Tourist Train Line | 523.1 | | 455 | 0 | 0 |
| | | Extra Length between Turnouts | | 72.5 | | | | | | | | |
| | | **Total** | | **3662.0** | | | | **712.6** | | | | **0** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Kasaragod RORO | | | | | | RORO Loop 1 | 757.6 | | 700.0 | | 0 |
| | | | | | | | RORO Loop 2 | 717.2 | 168.8 | 700.0 | | 0 |
| | | | | | | | Connection Line to RORO | 509.4 | | | | |
| | | | | | | | Shunting Neck | 57.0 | | 50.0 | | 1 |
| | | | | | | | RORO Loading A | 873.8 | | 800.0 | | 0 |
| | | Extra Length between Turnouts | | | | | | 168.8 | | | | |
| | | **Total** | | | | | | **3083.8** | | | | **1** |
| 16 | Kasaragod Depot | | Test Track | 1435.0 | | | | | | | 2 | |
| | | | | | | | Connection to depot 1 | 703.3 | | | | 0 |
| | | | | | | | Connection to depot 2 | 706.0 | | | | 0 |
| | | | | | | | Inspection Bay Line 1 | 599.6 | | 511.0 | | 1 |
| | | | | | | | Inspection Bay Line 2 | 600.0 | 6.5 | 511.0 | | 1 |
| | | | | | | | Inspection Bay Line 3 (Future) | 560.1 | | 535.0 | | 1 |
| | | | | | | | Inspection Bay Line 4 (Future) | 561.4 | 13 | 535.0 | | 1 |
| | | | | | | | Stabling Bay Line 1 | 599.2 | | 550.0 | | 1 |
| | | | | | | | Stabling Bay Line 2 | 639.9 | | 591.0 | | 1 |
| | | | | | | | Stabling Bay Line 3 | 519.2 | 26 | 449.0 | | 1 |
| | | | | | | | Stabling Bay Line 4 | 519.2 | | 449.0 | | 1 |
| | | | | | | | Stabling Bay Line 5 | 519.2 | 6.5 | 447.0 | | 1 |
| | | | | | | | Stabling Bay Line 6 | 519.7 | | 435.0 | | 1 |
| | | | | | | | Stabling Bay Line 7 (Future) | 602.1 | 6.5 | 435.0 | | 1 |
| | | | | | | | Stabling Bay Line 8 (Future) | 562.9 | | 434.0 | | 1 |
| | | | | | | | Stabling Bay Line 9 (Future) | 602.1 | 13 | 434.0 | | 1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Stabling Bay Line 10 (Future) | 562.9 | 6.5 | 430.0 | | 1 |
| | | | | | | | Stabling Bay Line 11 (Future) | 564.2 | | 430.0 | | 1 |
| | | | | | | | Stabling Bay Line 12 (Future) | 605.9 | 6.5 | 434.0 | | 1 |
| | | | | | | | Stabling Bay Line 13 (Future) | 567.4 | 6.5 | 434.0 | | 1 |
| | | | | | | | Stabling Bay Line 14 (Future) | 568.9 | | 520.0 | | 1 |
| | | | | | | | Stabling Bay Line 15 (Future) | 734.3 | | 613.0 | | 1 |
| | | | | | | | ARME Siding | 507.1 | 575.08 8 | 469.0 | | 1 |
| | | | | | | | BD Special Siding | 467.1 | 6.5 | 429.0 | | 1 |
| | | | | | | | P Way Siding | 427.1 | 6.5 | 389.0 | | 1 |
| | | | | | | | Tourist Train Siding | 387.1 | 6.5 | 353.0 | | 1 |
| | | | | | | | Connection to Test track | 84.0 | | | | 0 |
| | | | | | | | RRV Line | 156.3 | | | | 1 |
| | | Extra Length between Turnouts | | | | | | 685.6 | | | | |
| | | **Total** | | **1435.0** | | | | **15131.8** | | | **2** | **23** |
| | | | | | | | | **Deductions** | | | | |
| 17 | Embeded track Deductions | | | | | | Workshop line at Kollam (420x9) | 3780.0 | | | | |
| | | | | | | | Un loading Bay | 420.0 | | | | |
| | | | | | | | RRV line at Kollam Depot | 30.0 | | | | |
| | | | | | | | RRV line at Thrissur RORO | 85.3 | | | | |
| | | | | | | | RRV Line at Kasaragod Depot | 156.3 | | | | |
| | | | | | | | Rail platform at Kollam | 230.0 | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Rail platform at Thrissur | 230.0 | | | | |
| | | | | | | | Rail Platform at Kannur | 230.0 | | | | |
| 18 | Coloumn tracks Deductions | | | | | | Kollam IBL 5*420 | 2100.0 | | | | |
| | | | | | | | Kasaragod IBL* 420 | 1680.0 | | | | |
| | | | | | | | Deduction for Column tracks 1x50 IN Work Shop | 50.0 | | | | |
| | | | | | | | | **8991.6** | | | | |
| | **Grant Total** | **Grant Total** | | **28592.3** | | | | **58860.7** | | | **4** | **79** |
| | **Grant Total** | **Main line(A&B DL)** | | **474124.0** | | | | | | | | |
| | | **OVERALL TRACK LENGTH** | | | | | **IN M** | **IN KM** | | | **Total Nos. of Buffer** | |
| 1 | | Balastless Track on Main line DL | | | | | **58061.0** | **58.1** | | | **1** | |
| 2 | | Balastless Track on Running line | | | | | **16899.1** | **16.9** | | | **0** | |
| 3 | | Ballastless Track On Non Running Line | | | | | **901.6** | **0.9** | | | **0** | |
| | | **OVERALL BALLATLESS TRACK** | | | | | **133922.7** | **133.9** | | | **1** | |
| 1 | | Ballasted On Main Line DL | | | | | **474124** | **474.1** | | | **4** | |
| 2 | | Ballasted On Running Line | | | | | **28592.3** | **28.6** | | | **4** | |
| 3 | | Ballasted On Non Running Line | | | | | **58860.7** | **59.1** | | | **79** | |
| | | **OVERALL BALLASTED TRACK** | | | | | **1035701** | **1035.7** | | | **87** | |
| | | **GRANT TOTAL OVERALL** | | | | | **1169623.7** | **1169.6** | | | **88** | |
| **Summary Of Embedded Track** | | | | | | | | | | | | |
| 1 | Embeded track | | | | | | Workshop line at Kollam (420x9) | 3780.0 | | | | |
| | | | | | | | Un loading Bay | 420.0 | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | RRV line at Kollam Depot | 30.0 | | | | |
| | | | | | | | RRV line at Thrissur RORO | 85.3 | | | | |
| | | | | | | | RRV Line at Kasaragod Depot | 156.3 | | | | |
| | | | | | | | Rail platform at Kollam | 230.0 | | | | |
| | | | | | | | Rail platform at Thrissur | 230.0 | | | | |
| | | | | | | | Rail Platform at Kannur | 230.0 | | | | |
| **Total** | | | | | | | | **5161.6** | | | | |

**Summary Of Track On column**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Coloumn tracks | | | | | | Kollam IBL | 2100.0 | | | | |
| | | | | | | | Kasaragod IBL | 1680.0 | | | | |
| | | | | | | | Deduction for Column tracks 1x50 IN Work Shop | 50.0 | | | | |
| | | **Grant Total** | | | | | | **3830.0** | | | | |

**Ballast Requirement**

| | | Description of track | Length in Km | Unit | Quantity /Km | Quantity In M3 | PSC Sleeper Qu/KM | PSC Sleeper Quantity in Nos |
|---|---|---|---|---|---|---|---|---|
| 1 | | Ballasted On Main Line | 474.124 | m3 | 5620 | 2664576.88 | 1667 | 1580729 |
| 2 | | Ballasted On Running Line | 28.59 | m3 | 2890 | 82625.1 | 1667 | 47660 |
| 3 | | Ballasted On Non Running Line | 58.86 | m3 | 2300 | 135378 | 1667 | 98120 |
| | | **Grant Total Quantity** | | | | **2882579.98** | **Total** | **1726509** |
| 1 | | Extra for Voids | | | 8% | 230606.3984 | | |
| | | **Grant Total Quantity** | | | | **3113186.378** | | |

| | | Requirement Of Sub Ballast | | | | | Quantity In M3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | Ballasted On Main Line | 474.124 | | | 5040 | 2389584.96 | | | |
| 2 | | Ballasted On Running Line | 28.59 | | | 2000 | 57180 | | | |
| | | **Grant Total Quantity** | | | | | **2446764.96** | | | |

### 8.6.5 General principles to determine platform width, length and other details:-

The following basic principles are followed to determine the dimensions of the station and its facilities to be shown in the station track layout plans have been considered;

- Determination of width of platform-
  Where both sides of an island type platform are used, width of 11.32 m or more at the center and 5m or more at the ends.
  Where one side of a separated or side type platform is used, width of 8m or more at the center and 5 m or more at the ends.
- Distance between tracks-
  The track-to track distance shall not be less than 4.5m.
  The distance between the track center and the edge of platform in straight sections-
  1.76 m for platforms handling stopping trains.
  1.80 m for platforms handling non-stopping trains.
- Effective track length - 410 m (length of platform) + 50 m (absolute stop control section) + 20 m (margin) = 480m on Main line and 1st Loop.
- Effective track length - 400m (length of platform) + 20 m (absolute stop control section) + 20 m (margin) = 440m on other Loops.
- Height of the platform- 1.250 m above rail level.

The above parameters are standard dimensions followed in many high speed lines and are similar to that adopted in Mumbai Ahmedabad High Speed Railway project. Adequacy of the width of the platforms are to be reviewed as per egress calculation for peak hours boarding/ alighting of stations, train capacity and the headways at the time of execution.

### 8.6.6 Cross Sections of Station Tracks and Platforms

The track layout cross sections developed for each station based on the above conditions are shown as **Figure below.** All the cross sections are prepared facing Thiruvananthapuram station.

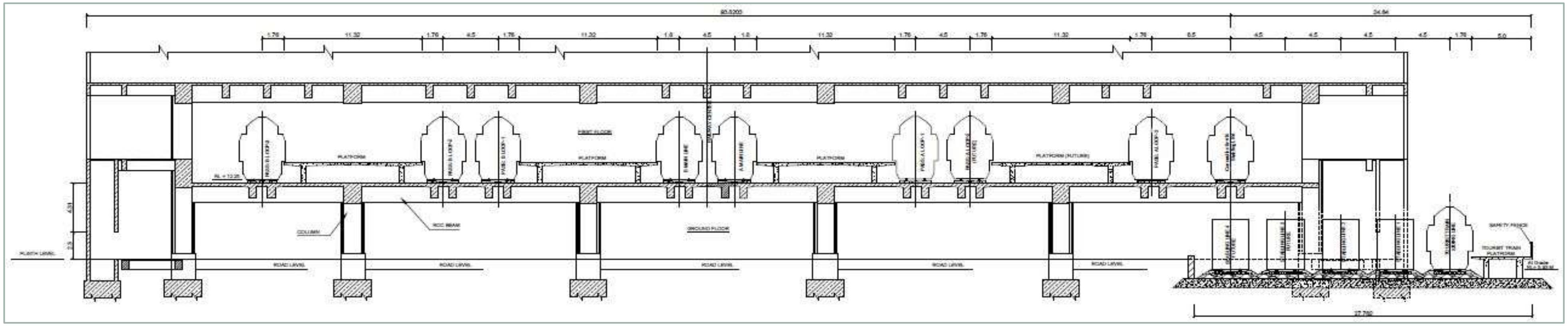


**Figure 8-22: Thiruvananthapuram Station (On Viaduct)**.

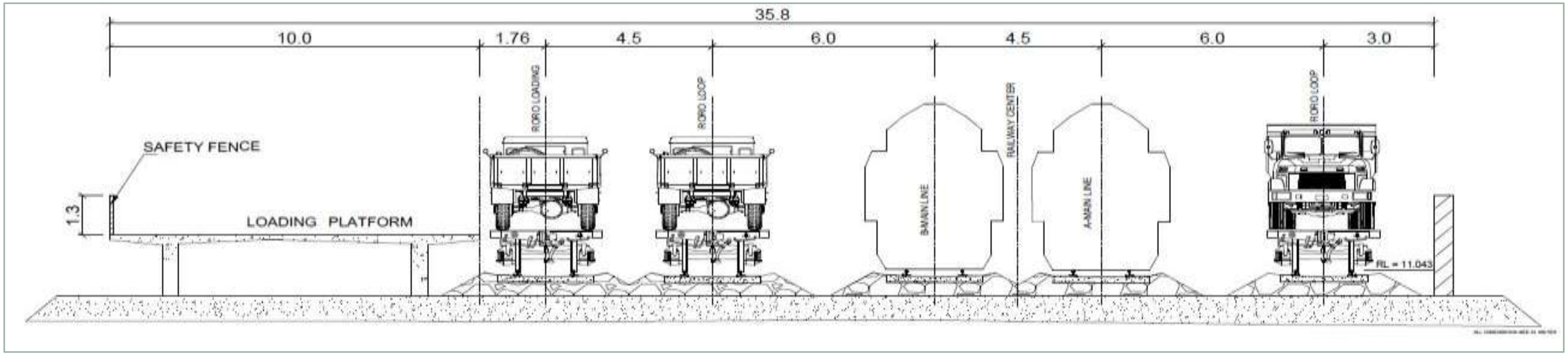



**Figure 8-23: Thiruvananthapuram RORO Station (At-Grade)**

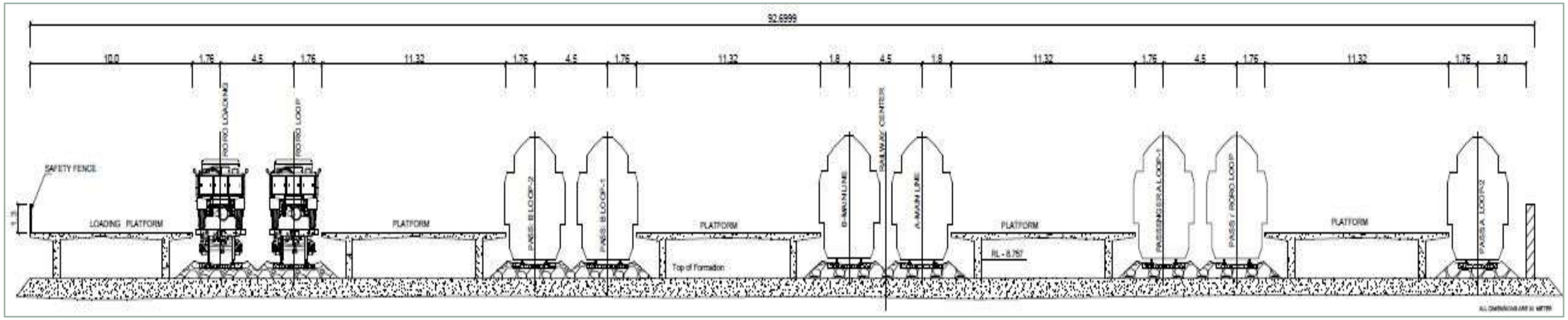



Figure 8-24: Kollam Station (At-Grade)

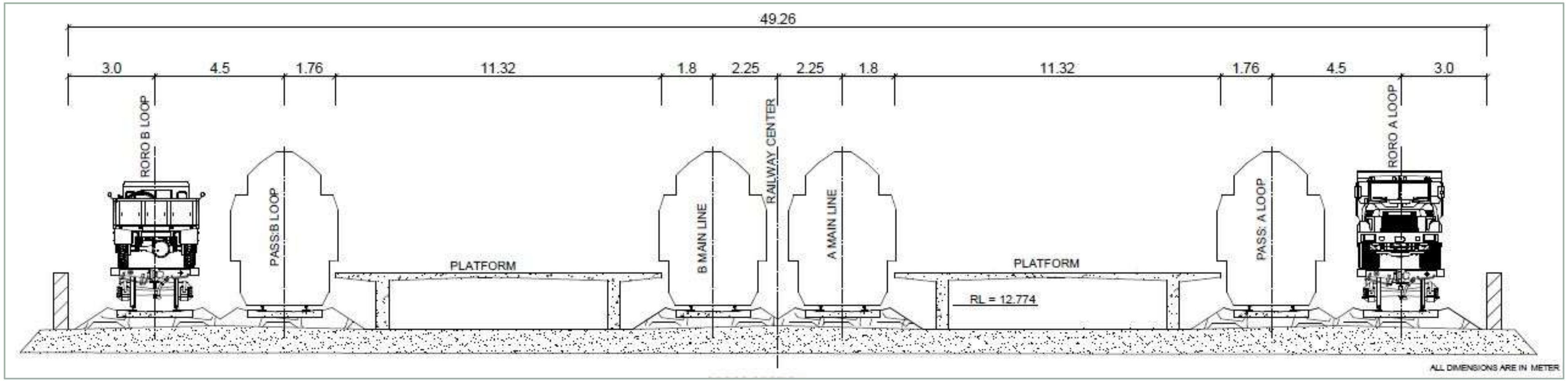



Figure 8-25: Chengannur Station (At-Grade)

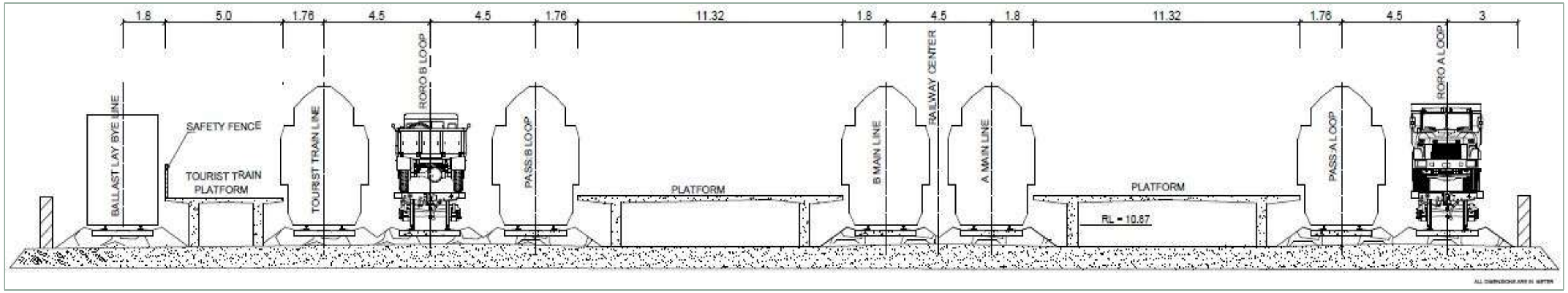



Figure 8-26: Kottayam Station (At-Grade)

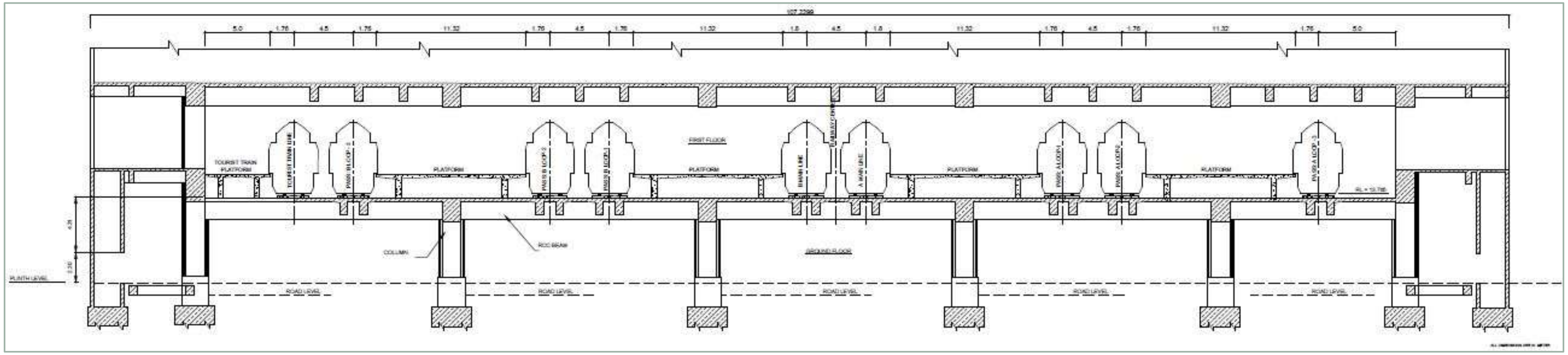


Figure 8-27: Ernakulam Station (On Viaduct)

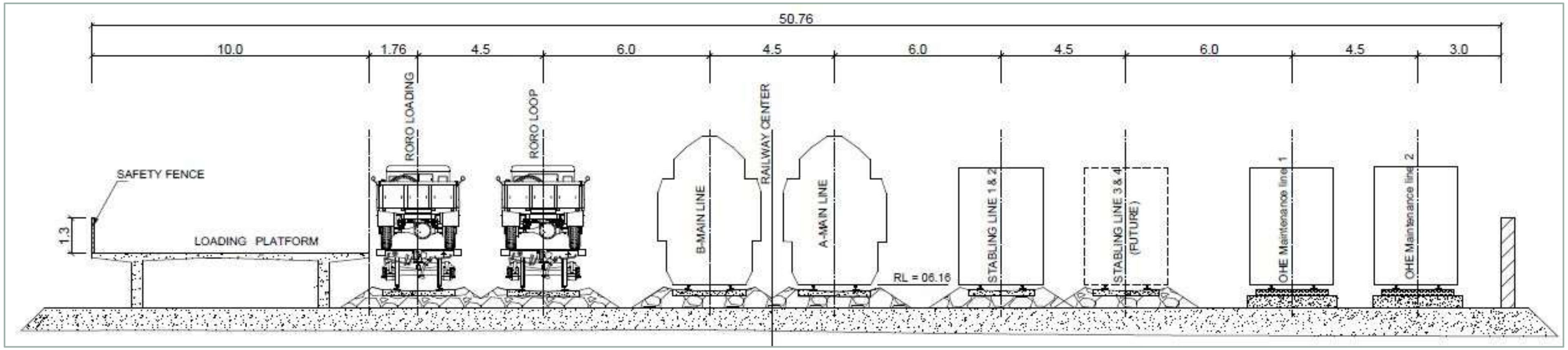



Figure 8-28: Ernakulam RORO Station (At-Grade)

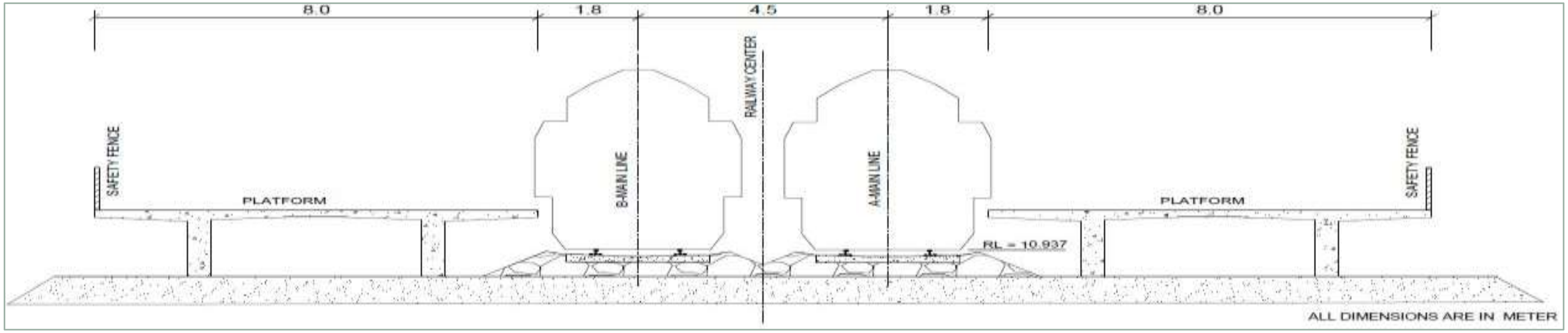



Figure 8-29: Kochi Airport Station (At-Grade)

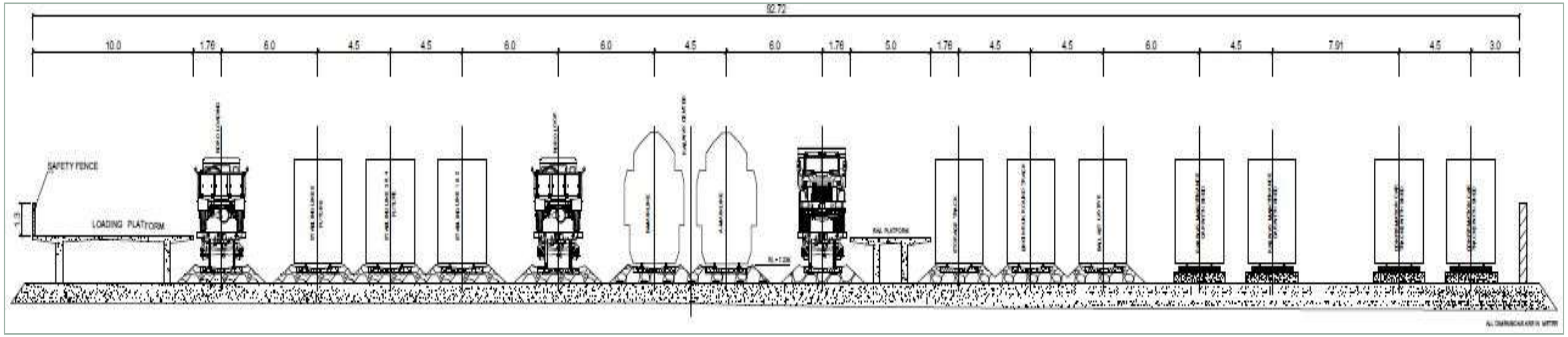


**Figure 8-30: Thrissur RORO Station (At-Grade)**

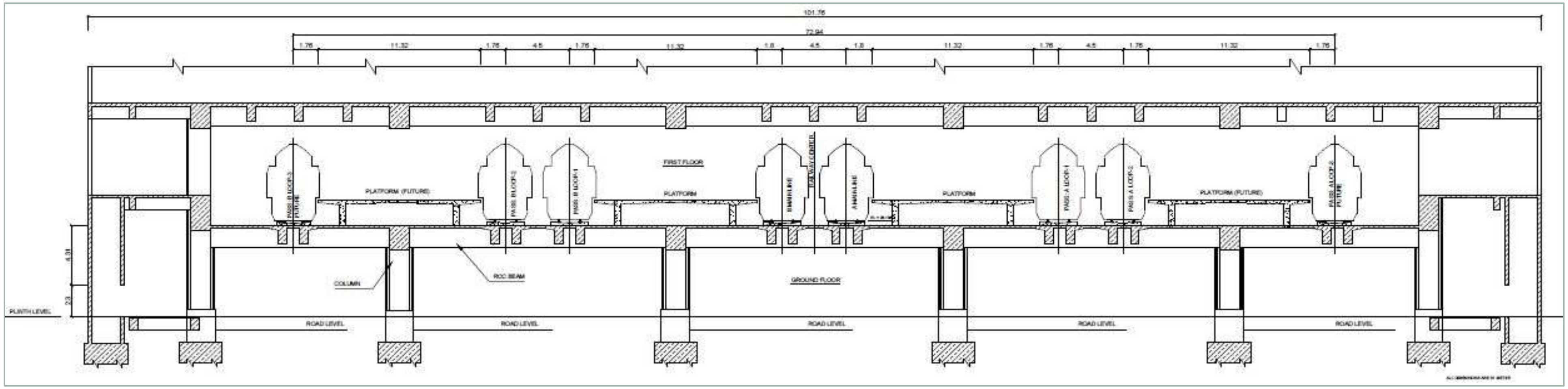


**Figure 8-31: Thrissur Station (On Viaduct)**

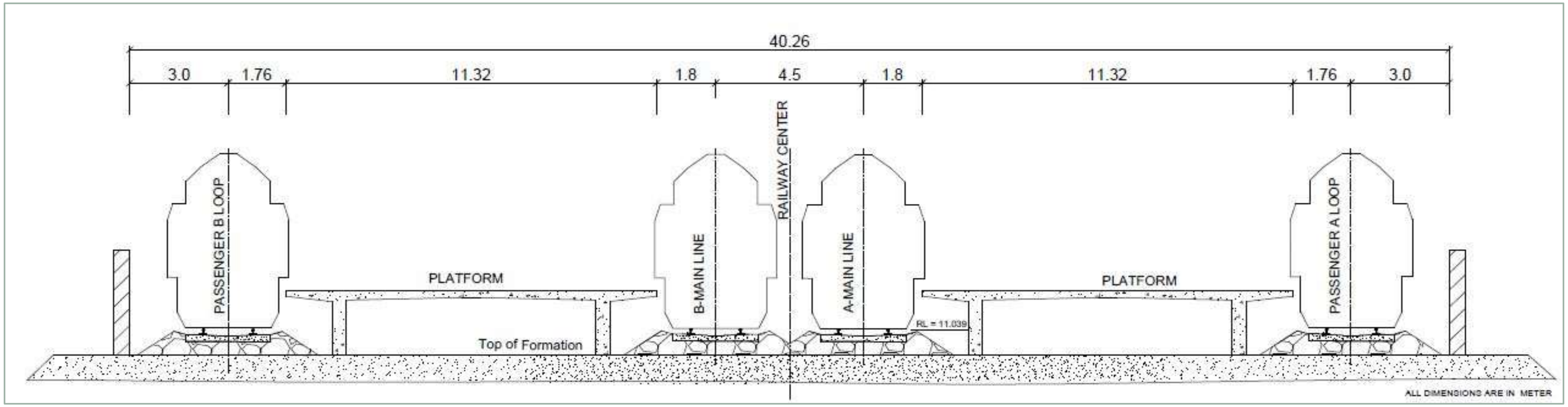



**Figure 8-32: Tirur Station (At-Grade)**

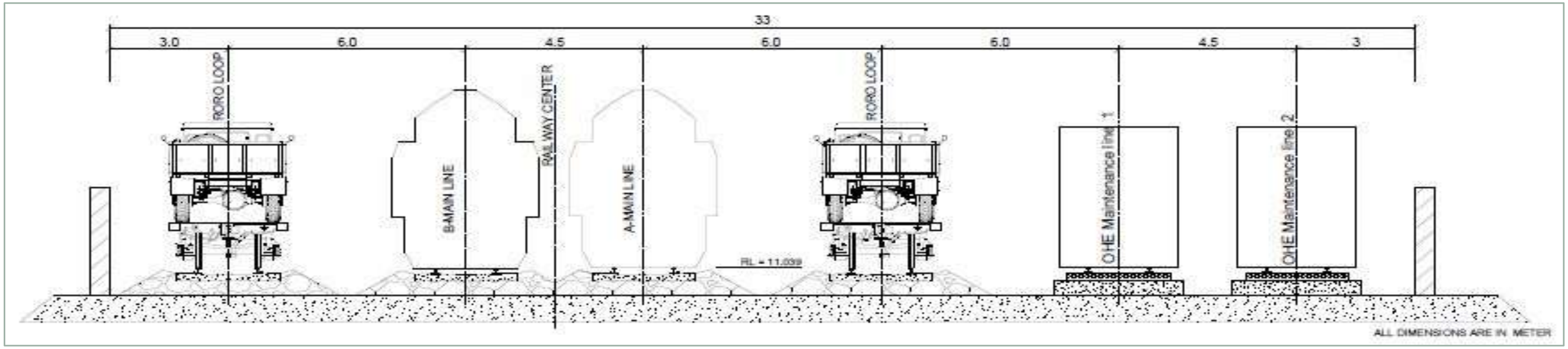



**Figure 8-33: Tirur RORO Station (At-Grade)**

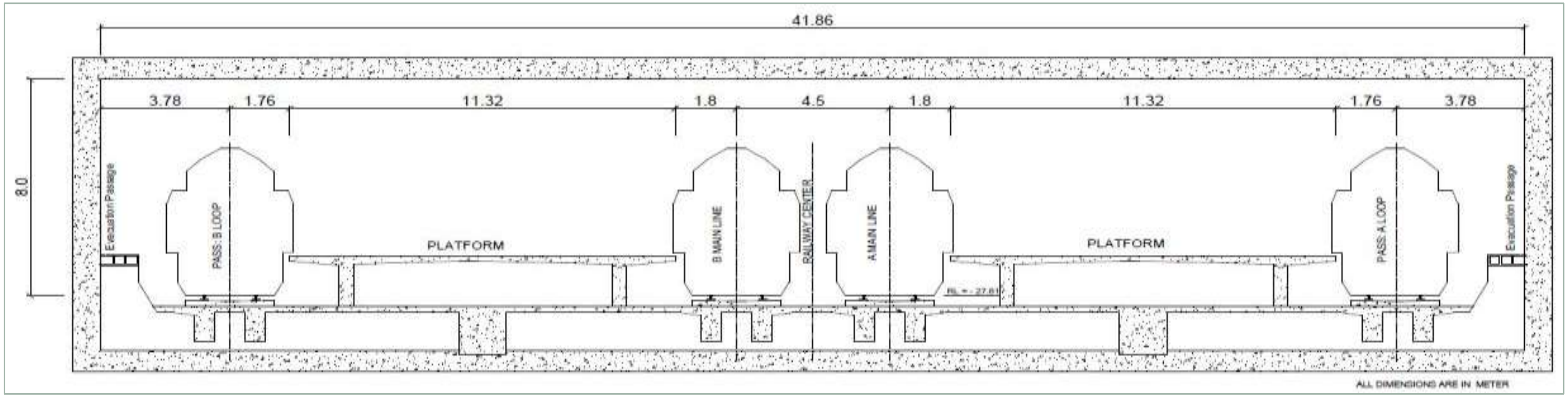



**Figure 8-34: Kozhikode Station  (Undergound)**

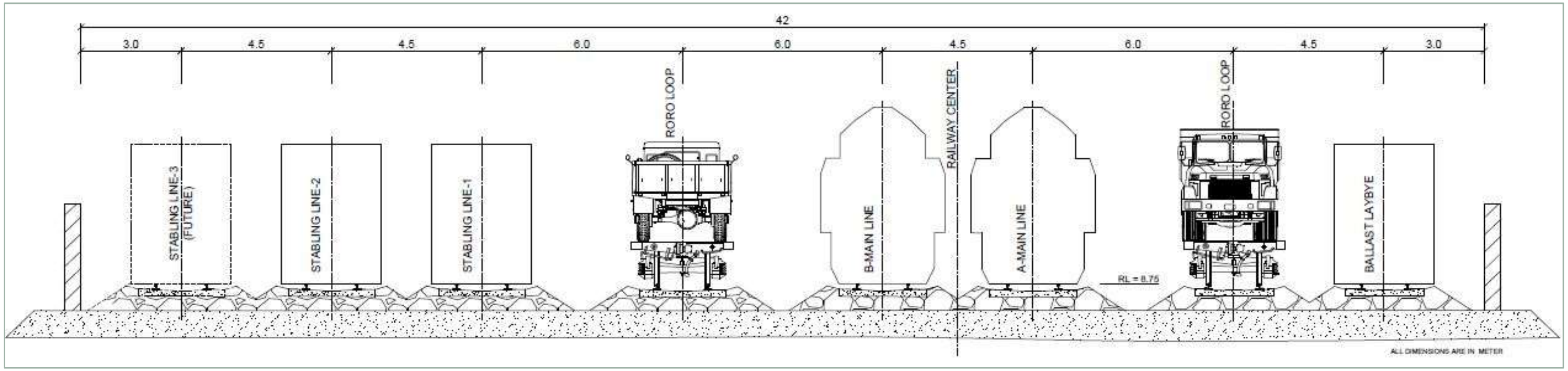



**Figure 8-35: Kozhikode RORO Station (At-Grade)**

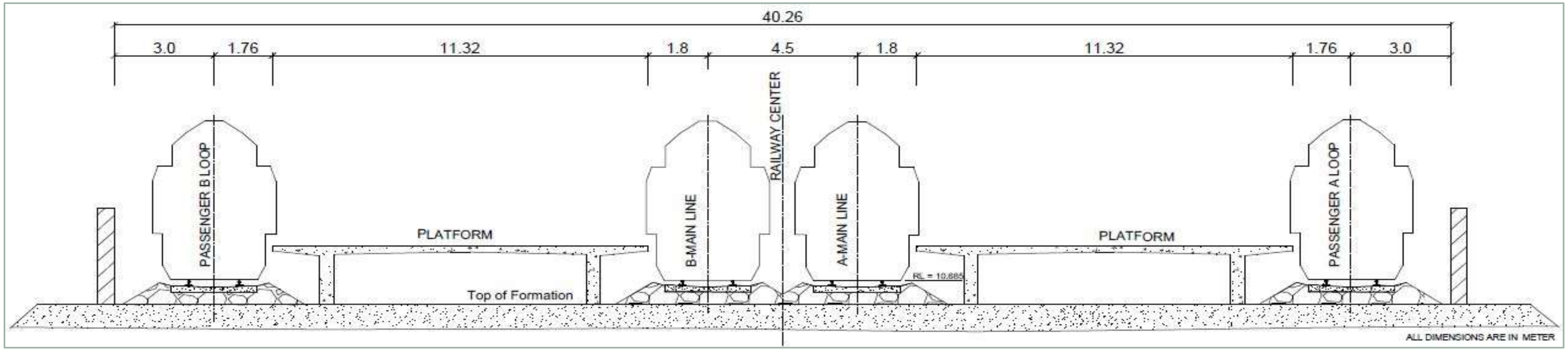



**Figure 8-36: Kannur Station (At-Grade)**

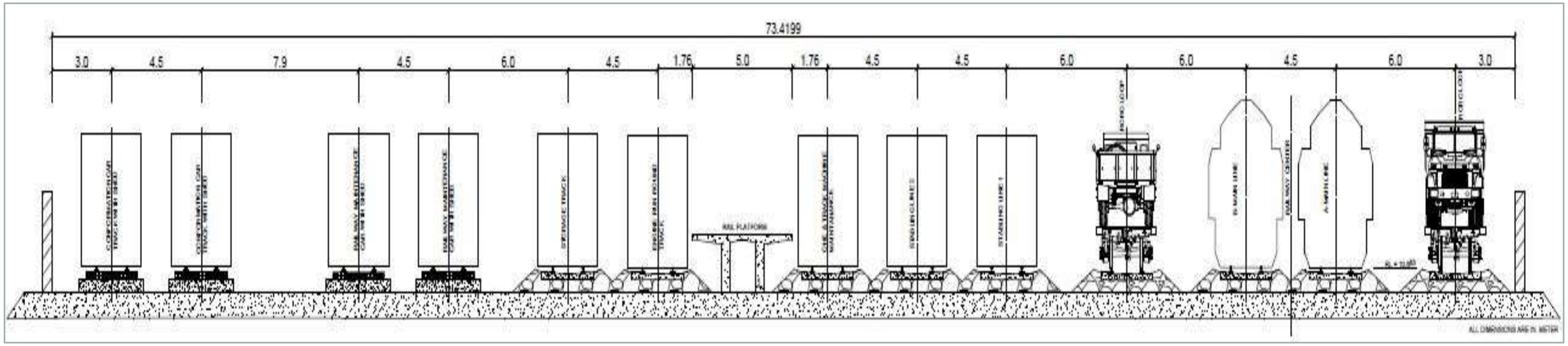



**Figure 8-37: Kannur RORO Station (At-Grade)**

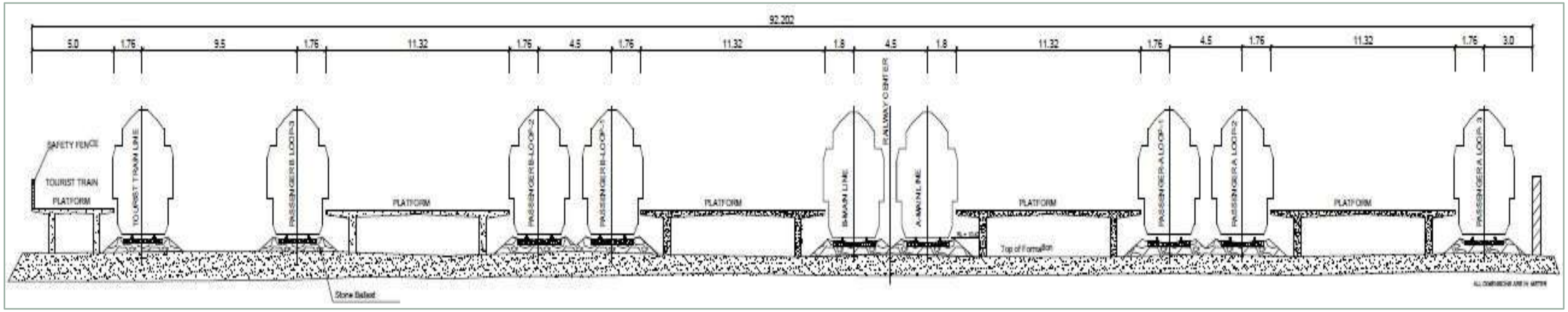



Figure 8-38: Kasaragod Station (At-Grade)

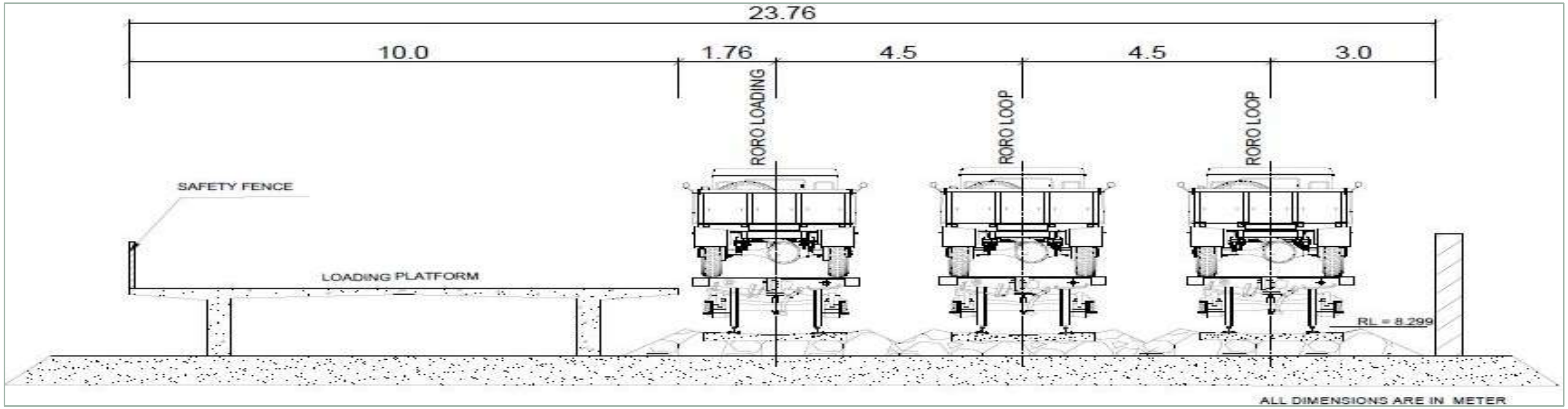



Figure 8-39: Kasaragod RORO Station (At-Grade)

### 8.6.7 Classification Of Stations:-

As per the ridership and the station loads, the proposed stations in the project have been classified into 3 categories as Class A, B and C stations depending on the importance and other requirements of the stations as described hereunder;

- **CLASS 'A' Stations**

Seven proposed stations namely Thiruvananthapuram, Kollam, Ernakulam, Thrissur, Kozhikode, Kannur and Kasaragod are categorized as Class 'A' stations. All the seven stations except Kasaragod are situated in Corporation areas where high ridership is anticipated. Kasaragod station is planned as class 'A' station being a Terminal station.

- **CLASS 'B' Stations**

Three proposed stations namely Chengannur, Kottayam and Tirur Stations are classified as Class 'B' stations. They are all situated in Municipalities and are expected to serve less ridership.

- **CLASS 'C' Stations**

Kochi International Airport Station is classified as Class 'C' station as it is a halt station.

The station facilities and their standards will be decided according to their classes.

## 8.7 TRACK STRUCTURE:

### 8.7.1 Rail

It is proposed to have continuous welded rails for the SilverLine due to following advantages over conventional fish plated track:

- It ensures better safety since there is no possibility of fish plates opening up or being tampered while in service.
- It provides more riding comfort with less noise and vibrations.
- It requires less maintenance both for track components and rolling stock.

While the CWR track can be welded into a single rail from station to station, the current practice is to have switch expansion joints at regular intervals, in order to determine if there are any thermal stresses built up and relieve the same without having to cut the rails. However, in case the likely effect of rail expansion / thermal stresses is to be taken care of in Viaduct design or in the track structure or at the junction of varying mediums of elasticity of track, suitable design of all structures shall be ensured. Continuing CWR through bridges shall be subject to specific design rules in view of anticipated interaction between bridges and track. CWR is not proposed to be

continued through the points and crossings, however, if the same is required at any stage, appropriate design in the form of stress frame/ anti-creep devices have to be suitably provided. These aspects shall be considered during detail design stage.

The rails should be welded by flash butt welding, which can be done easily now a days by mobile welding plants. Welding robots are also being used for welding the rails. Thermic welding should be used only where flash butt welding is not possible for some reason.

The rail recommended to be used in 60 kg UIC 60/60E1 head hardened rails conforming to grade 1080 with suitable elastic fastening system over PSC sleepers on normal track or RCC embedded blocks in Ballast less track in tunnels and viaducts (more than 2kms) with sleepers spaced at 60 cms. The fastening system shall be elastic fastening for normal track and Vozlo system 300 or similar type of elastic fastening for ballastless track.

For non-running lines, 60 Kg PSC sleeper at 60 cm spacing to have a uniform spacing is proposed, even though the minimum spacing required is only 65 cm, for facilitating easy mechanical maintenance with different tamping machines. For non-running lines 60 kg- 90UTS- 880 grade rail conforming to IRS T-12-2009 will be used. Spacing for non-running lines may be reviewed at the time of execution. Cross section of rail is shown in the **Figure below**.

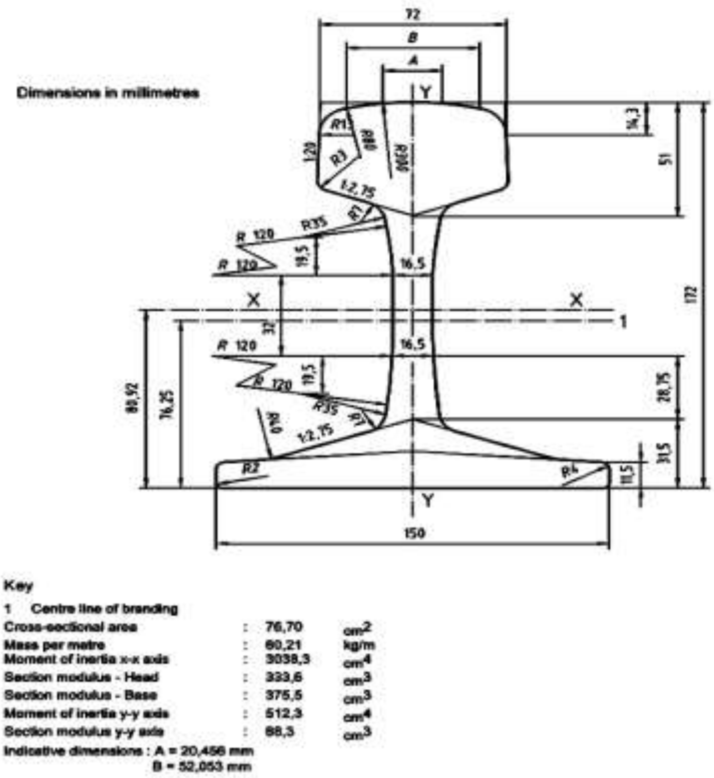



**Figure 8-40: Cross Section Of 60 Kg Rail**

Specifications of 880 Grade rails are given in **Table 8-9** below. That for 1080 grade shall be decided at the time of execution based on the availability.

**Table 8-9: The specifications for 880 grade Non Running Lines**

| Grade | Chemical Composition (percentage) | | | | | | | | | | | Mechanical Properties | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | Mn | Si | S (max) | P (max) | Al (max) | Mo (max) | Cr | V (max) | $10^{-4}$% ( ppm) max by mass O | Hydrogen content in liquid steel (max.) | UTS (MPa) (Min) | Yield Strength ***(MPa)(Min.) | Elongation % on gauge length – 5.65 √So (min) | Running surface hardness (BHN) |
| 880 | 0.60-0.80 | 0.80-1.30 | 0.10-0.50 | 0.030* | 0.030* | 0.015 | - | - | - | - | 1.6 ppm | 880 | 460 | 10.0 | Min 260** |
| 1080 Cr | 0.60-0.80 | 0.80-1.20 | 0.50-1.10 | 0.025 | 0.025 | 0.004 | 0.20 | 0.80-1.20 | 0.20 | 20 | 1.6 ppm | 1080 | 560 | 9.0 | 320-360 |
| 1080 HH | 0.60-0.80 | 0.80-1.30 | 0.10-0.50 | 0.030* | 0.030* | 0.015 | - | - | - | - | 1.6 ppm | 1080 | 460 | 10.0 | 340-390 |

### 8.7.2 Turnouts:

#### 8.7.2.1 Turnouts

It is provided to help transfer railway vehicles from one track to another. The tracks may be parallel to, diverging from, or converging with each other. Points and crossings are necessary because the wheels of railway vehicles are provided with inside flanges and, therefore, they require this special arrangement in order to navigate their way on the rails. The points or switches aid in diverting the vehicles and the crossings provide gaps in the rails to help the flanged wheels to roll over them. A complete set of points and crossings, along with lead rails, is called a *turnout*.

The following terms are often used in the design of Turnouts

It is an arrangement of points and crossings with lead rails by means of which the rolling stock may be diverted from one track to another. Switches and crossings shall comply with the necessities of high-speed operations. Speeds along the normal direction of turnout, shall comply with the main line design speed regardless of the allowed speed on the diverging route.

The primary function of frequently and intensively used turnouts are to perform as connections to the station platform tracks. Since these will be heavily used, the geometry selected is based on minimizing forces for the twin objects of improved ride quality and low wear on the turnout components. The basic design concept followed for the high-speed turnouts should be based on the transitioned turnout design of the German Federal Railways.

Other turnouts, including the main line crossovers which are anticipated to be used in disturbed operations and for maintenance only, should be based on the designs given in UIC Code 711 and other designs commonly used in Europe.

#### 8.7.2.2 Technical Specification of Turnouts:-

a) All the points to be capable of being operated by electric motors in accordance with the signaling specification.

b) The top surfaces of PSC sleeper/RCC slab supporting rail seat of turnouts and scissors crossover shall be flat without any cant/slope.

c) The track form of the turnout shall have uniform resilience as that of the adjoining track form.

d) The fixation of turnouts, scissor cross-over on track slab shall be through base plates/bearing plates with cant 1 in 20 as coning of wheel proposed is 1 in 20.

### 8.7.2.3 Rails for turnouts:-

The rails used for manufacturing of turnouts shall comply the following conditions:

a) The rails used in turnouts shall be 1080 grade Head Hardened. However, rails used in turnouts on depot and other non-running lines may be of 880 grades.

b) The rails shall be manufactured and tested in accordance with IRS/T-12-2009 with latest amendment.

c) The section of rails shall be 60E1 (UIC60) for stock, lead and 60E1A1 (ZU1- 60) /60E1A4 for switch rail.

d) The rails shall qualify as Class ‘A’ rails as per IRS/T-12-2009.

e) The rails shall be with ends un-drilled.

f) The 1080HH rail to be suitable for being welded by alumino-thermic or flash butt welding technique.

**Figure below** shows the nomenclature for various components in a layout.

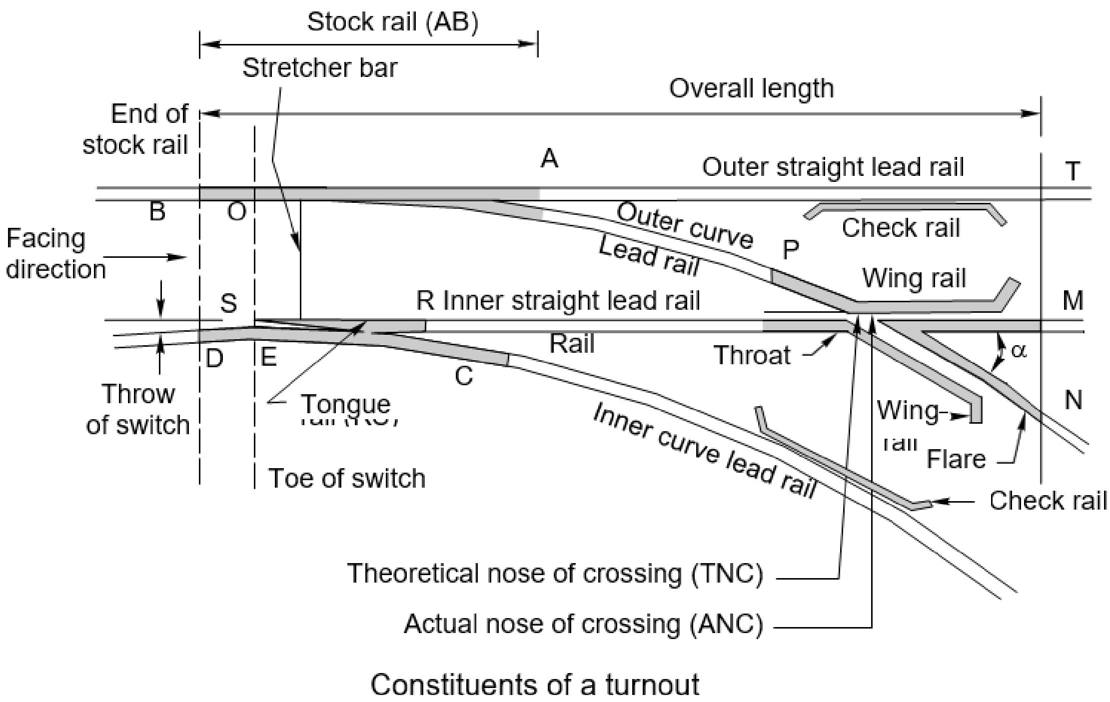



**Figure 8-41: Constituents of a Turnout**

### 8.7.2.4 General technical Specifications of Switches to be used:-

1. Each switch device shall consist of two stock rails, one left hand and one right hand and two switch rails, one left hand and one right hand.
2. The switch rail shall be one piece with no weld or joint within the switch rail length.

3. The end of the asymmetrical switch rail shall be forged to 60E1 (UIC60) rail profile with minimum length of 500 mm. The forged switch rail end shall be suitable for welding or installation of insulated rail joint.
4. Slide chairs in the switch portion shall be coated with an appropriate special coating, so as to reduce the point operating force and to eliminate the requirement of lubrication of sliding surfaces during service.
5. Switches shall provide suitable flange way clearance between the stock rail and the switch rail with the switch rail in open position (minimum 60mm). The 1 in 18 with 1106 m radius, 1 in 9 with radius of 300 m and flatter turnouts shall be provided with second drive or other suitable arrangement to ensure minimum gap of 60mm at JOH as well as proper housing of switch rail with stock rail up to JoH. The normal opening of switch at toe of switch shall be kept as 160mm.
6. The switch manufacturer shall include provision for all holes required to main drive machines, stretcher bars and detection equipment to suit the requirements of the signaling and switch operating system duly chamfered to avoid stress concentration at the edge of the holes.
7. The switches shall be designed with an anti-creep device at the heel of switch to withstand thermal forces of the CWR track.
8. The switches and all slide chairs shall be same for ballasted and ballast less Track

#### 8.7.2.5 Direction of a turnout:-

A turnout is designated as a right-hand or a left-hand turnout depending on whether it diverts the traffic to the right or to the left. The direction of a point (turnout) is known as the facing direction if a vehicle approaching the turnout or a point has to first face the thin end of the switch. The direction is trailing direction if the vehicle has to negotiate a switch in the trailing direction i.e., the vehicle first negotiates the crossing and then finally traverses on the switch from its thick end to its thin end. Therefore, when standing at the toe of a switch, if one looks in the direction of the crossing, it is called the facing direction and the opposite direction is called the trailing direction.

- **Tongue rail -** It is a tapered movable rail, made of high-carbon or -manganese steel to withstand wear. At its thicker end, it is attached to a running rail. A tongue rail is also called a *switch rail.*

- **Stock rail** - It is the running rail against which a tongue rail operates.

- **Points for switch** - A switch consists of a pair of tongue and stock rails with

sliding chairs, necessary connections and fittings. Constituents of a switch is shown in **Figure below.**

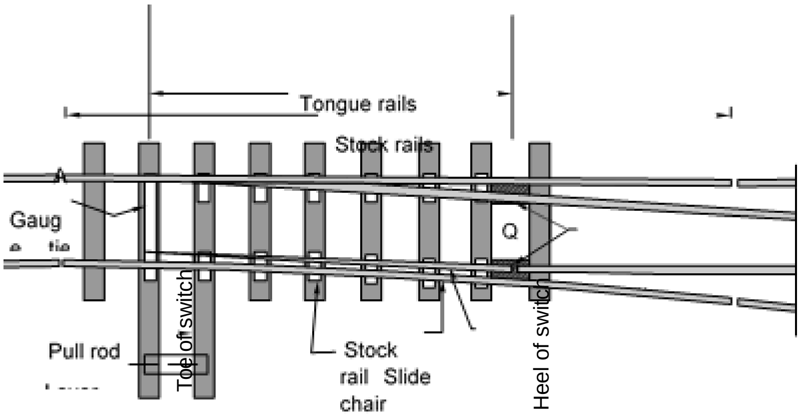



**Figure 8-42: Constituents of a Switch**

**(iv) Crossings -** A crossing is a device introduced at the junction where two rails cross each other to permit the wheel flange of a railway vehicle to pass from one track to another. Constituents of the crossing assembly is shown in **Figure below**;

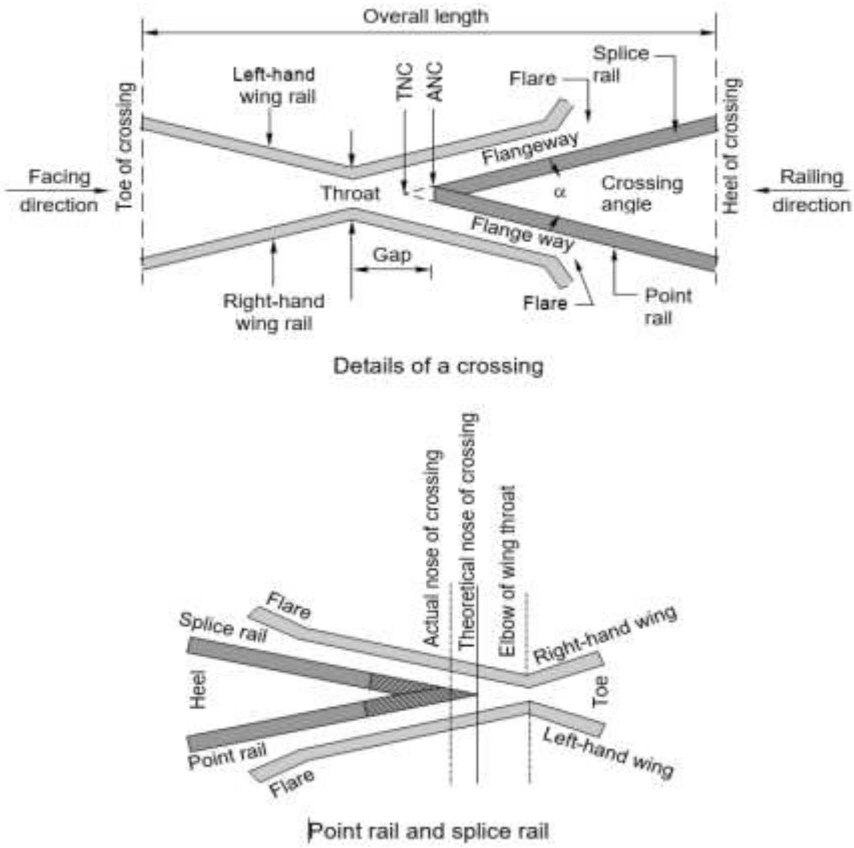



**Figure 8-43: Constituents of a Crossing**

#### 8.7.2.6 Specifications for Crossings:-

1. All crossings shall be cast manganese steel (CMS) crossings with weldable rails of minimum 1.2m length undrilled for welding into the overall turnout.

2. The CMS crossings shall be manufactured from Austenitic Manganese steel as per UIC 866.

3. All CMS crossings shall have welded leg extensions of 60E1 (UIC60) rails. This shall be achieved by flash butt welding of buffer transition rail piece of suitable thickness to CMS crossings and rail leg extension.

4. All CMS crossings on main line shall have a minimum initial hardness of 340 BHN.

5. All CMS crossings and their welded leg extensions for all scissor crossovers shall be suitably dimensioned so as to eliminate the necessity of providing small cut rail pieces for the purpose of inter-connection. However, the need for providing insulated glued joints from signaling requirement point of view shall be taken care of in the design, if required.

6. The provision of rail cant shall be taken care of on the top surface of the CMS crossing and the bottom surface of all CMS crossing shall be flat.

#### 8.7.2.7 Different turnouts used for SilverLine project:-

Following two types of the turnouts are proposed for the SilverLine system track connections.

i) 1 in 18 thick webbed with movable crossings.
ii) 1 in 9 thick webbed with moveable crossings on mainlines and 1 in 9 thick webbed with fixed crossing for other lines.

- **1 in 18 thick webbed with movable Crossing -**

Following are the turnout combinations proposed for track connections in SilverLine;

a. 1 in 18 (1106) LH and RH Turnouts
b. 1 in 18 LH and RH Crossovers
c. 1 in 18 Scissors Crossovers
d. 1 in 9 (300) LH and RH Turnouts
e. 1 in 9 (600) Symmetrical splits
f. 1 In 9 LH and RH Crossovers

g. 1 in 9 Scissors Crossovers

- **1 in 18 (1106) LH and RH Turnouts –**

1 in 18 turnouts are proposed for the first loops of all stations for A and B lines and for the loop line connecting to depot at Kollam to facilitate easy reception and dispatch. For this Turnouts Movable Crossings are proposed. 1 in 18 represents the angle of crossing and the 1106 represents the radius of the lead curve. It is also used for crossovers and scissors cross overs wherever necessary. The crossing proposed are with Shinkansen Type movable Nose. A photograph of Shinkansen Type crossing with movable Nose is shown in **Figure 8-46.** SRJ to the HOC for this Turnout is 64.856 m which is known as the overall length. **The designed speed potential of the turnouts is 80 kmph**. For setting of point the length from SRJ(Stock Rail Joint) to the Meeting point or intersection point (‘A’ Distance), Meeting point to the HOC (Heel of Crossing) of main line as well as loop line which are known as ‘B’ distance and ‘C’ distance respectively are required. The ‘A’, ‘B’ and ‘C’ distances are respectively 32.886,31.970 and 31.970 respectively which ae shown in the **Figure 8-45** and the constituents of a LH turnout is shown in **Figure 8-44**;

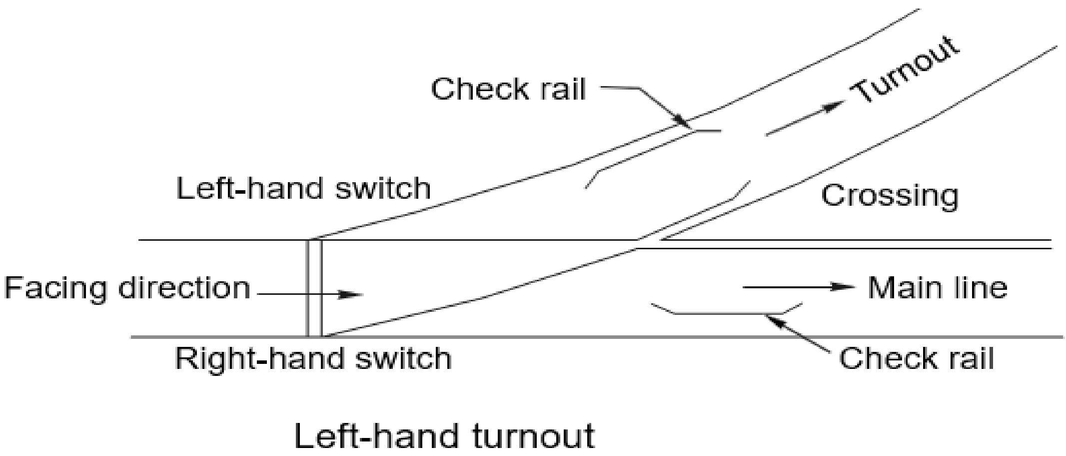



**Figure 8-44: Constituents of a Left Hand turnout**

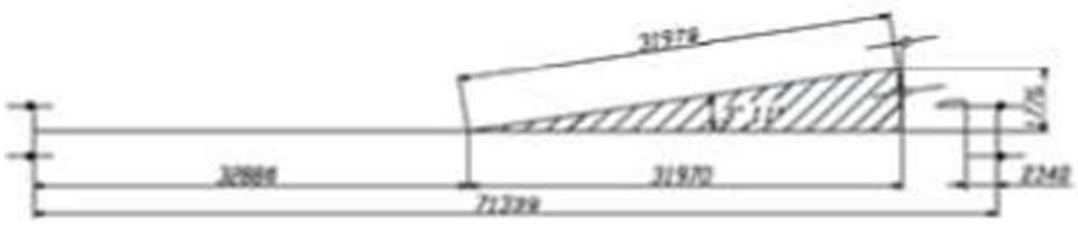


**Figure 8-45:**

**Dimensions of a 1 in 18 Turnout**

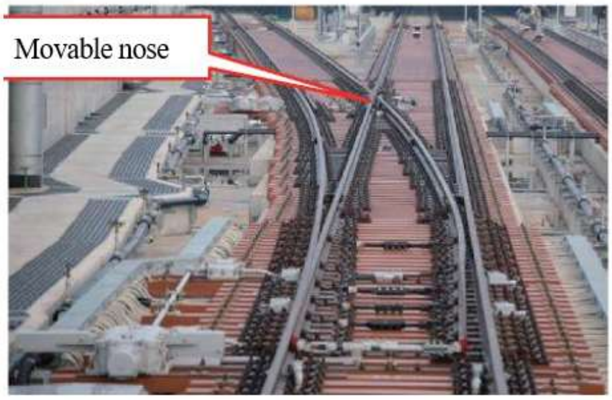



**Figure 8-46: Picture of Shinkansen Type 1 in 18 Turnout with movable Crossing**

- **1 in 18 LH and RH Crossovers –**

A device used for the movement of one train from one parallel line to another parallel line is known as a crossover. The speed potential of the Cross over is 80 Kmph. It is made of two turnouts arranged face to face with a straight track in between as shown in the **Figure below**;

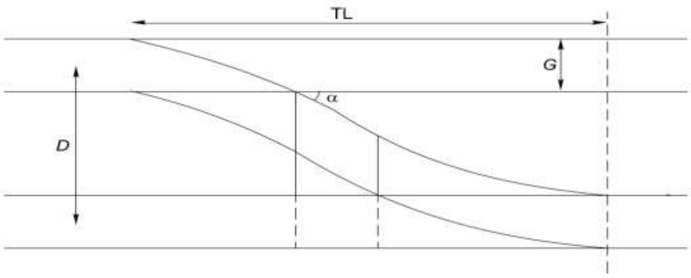



**Figure 8-47: Showing RH Crossover between two parallel tracks**

Total length of crossover is given by the formula **TL= α D+2A**

In our case α is 18, D is 4.5 and A is 32.886. Therefore TL=18X4.5+2X32.886 = 146.772. When the turn outs used are LH the crossover will be known as LH crossover and the overall length will remain the same

- **1 in 18 Scissors Crossovers –**

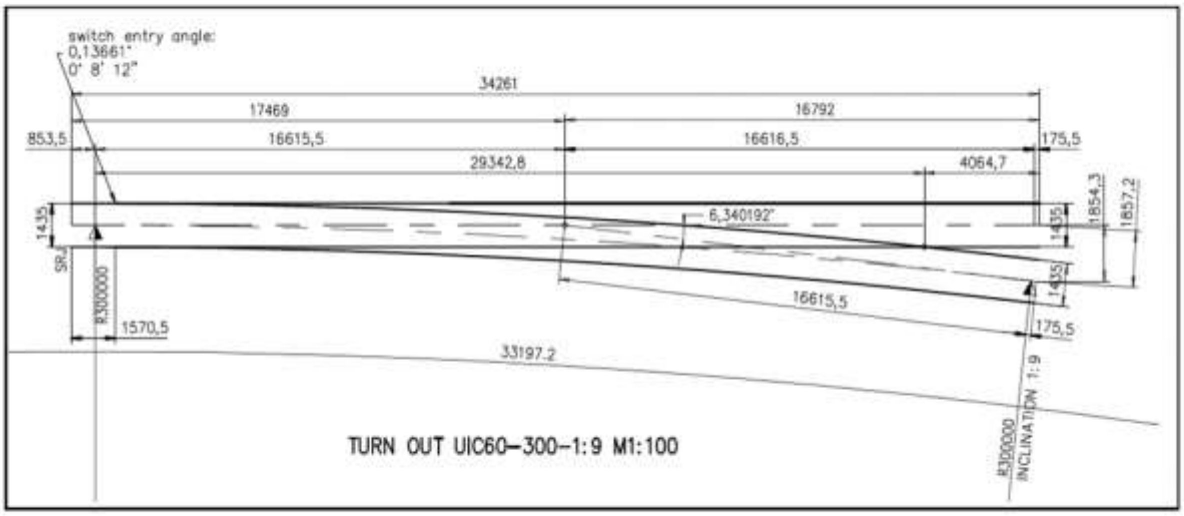
A scissors crossover is meant for transferring a vehicle from one track to another track and vice versa. It is provided where lack of space does not permit the provision of two separate crossovers. It consists of four pairs of switches, six acute crossings, two obtuse crossings, check rails, etc. The speed potential of the Scissors Crossover also is 80 Kmph.

Total length of crossover is given by the formula TL= α D+2A stands good for scissors cross-over also i.e. = 146.772 m.

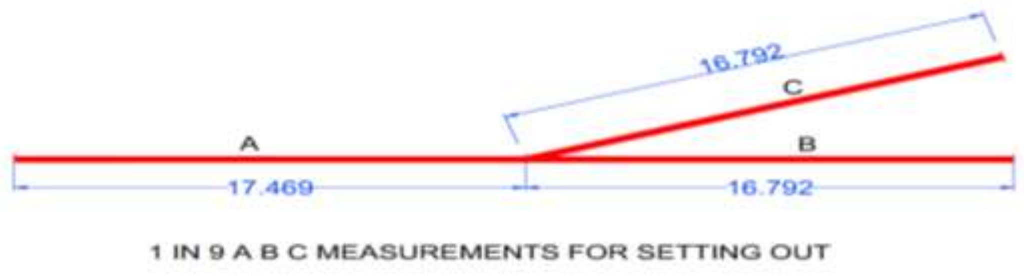
A Photograph showing a scissors Crossover is shown in **Figure below**;

**Figure 8-48: 1 in 9 (300) LH and RH Turnouts**

1 in 9 turn outs are proposed for all the loops other than the first loops of all stations and the 3rd loop on A line connecting the Depot at Kollam. 1 in 9 represents the angle of crossing and the 300 represents the radius of the lead curve. It is also used for crossovers and scissors cross overs wherever necessary. The speed potential of this turnout is considered as 45 Kmph. SRJ to the HOC for this turnout is 34.261 m which is known as the overall length. For setting of point the length from SRJ (Stock Rail Joint) to the Meeting point or intersection ('A' Distance), Meeting point to the HOC (Heel of Crossing) of main line as well as loop line which are known as 'B' Distance and 'C' distance respectively are required. The 'A', 'B' and 'C' distances are respectively 17.469,16.792 and 16.792 respectively as shown in **Figure below**.




**(i)**




(ii)

**Figure 8-49: Design parameters of 1 in 9 turnout**

- **1 in 9 (600) Symmetrical splits –**

When a straight turnout splits up in two different directions with equal radii, the layout is known as a symmetrical split as shown in **Figure below.** In other words, a symmetrical split is a contrary flexure in which the radii of the two curves are the same. The speed potential of this turnouts is considered as 70 Kmph. However, as these turnouts are laid in between 1 in 9 turnouts the Speed is limited to 45 Kmph.

The salient features of a symmetrical split are the following.

(a) The layout consists of a pair of points, one acute angle crossing, four curved lead rails, and two check rails.

(b) The layout is symmetrical about the center line. This means that the radii of the main track as well as of the branching track are equal.

(c) The layout provides facilities for diverting vehicles both towards the left and the right.

(d) It is suitable for locations with space constraints, as it occupies comparatively much less space than a turnout from the straight track.

(e) The radii of the turnout are 600 m.

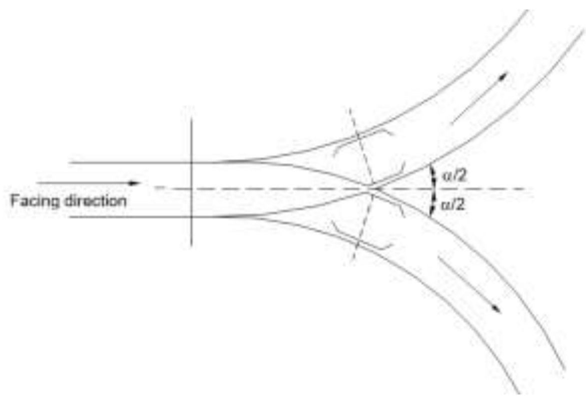



**Figure 8-50: Symmetrical Split**

- **1 In 9 LH and RH Crossovers –**

A device used for the movement of one train from one parallel line to another parallel line is known as a crossover. It is made of two turnouts arranged face to face with a straight track in between as shown in the sketch below (Typical RH Cross over is shown in **Figure below**. The speed potential of these crossovers **is 45 Kmph.**

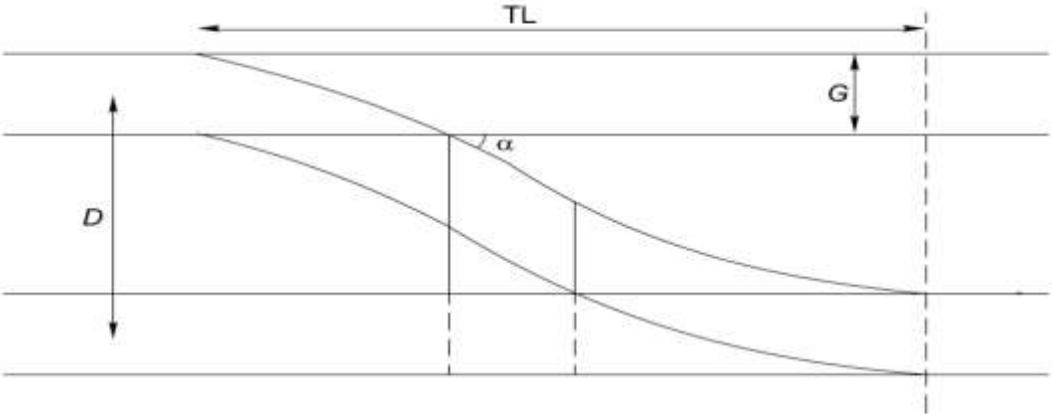



**Figure 8-51: RH Crossover between two parallel tracks**

Total length of crossover is given by the formula TL**= α D+2A**

In our case α is 9, D is 4.5 and A is 17.469

Therefore TL=9X4.5+2X17.469 =**75.438**

When the turn outs used are LH the crossover will be known as LH crossover and the overall length will remain the same.

- **1 in 9 Scissors Crossovers -**

A scissors crossover is meant for transferring a vehicle from one track to another track and vice versa. It is provided where lack of space does not permit the provision of two separate crossovers. The speed potential of these crossovers is also 45 Kmph.

It consists of four pairs of switches, six acute crossings, two obtuse crossings, check rails, etc. Total length of crossover is given by the formula TL= α D+2A stands good for scissors crossover also i.e. = 75.438m

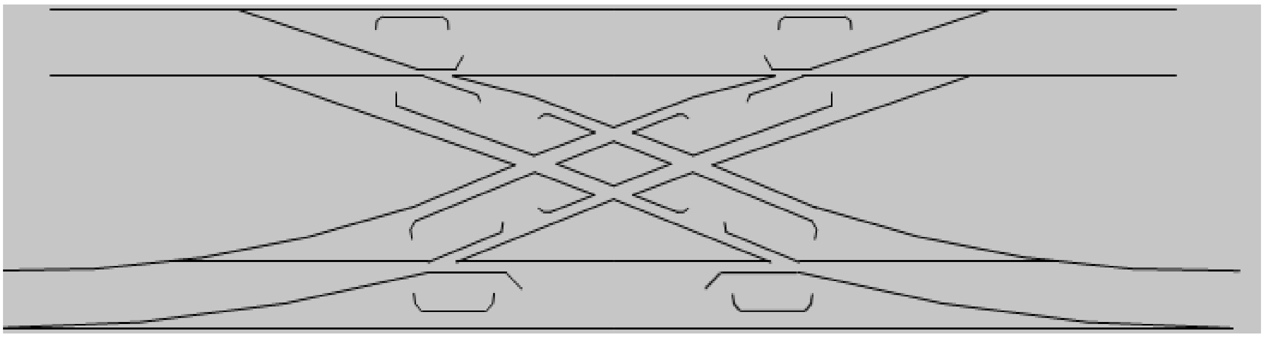


**Figure 8-52: 1 In 9 Scissors Cross Over**

### 8.7.2.8 Details of all turnouts proposed for SilverLine:-

The details of overall total no of turnouts proposed to be used are 385 as furnished in **Table below**.

**Table 8-10: Summary of Different Types of Track Connections**

| S.No. | Station No. | Station Name | 1 in 18 | | | | | 1 in 9 | | | | | | Grand Total | Total Nos of Turnouts | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 in 18 Turn Out | | 1 in 18 Cross over | | 1 in 18 Scissors cross over | 1 in 9 Turn out | | 1 in 9 Cross over | | 1 in 9 Symmetrical split | 1 in 9 Scissors cross over | | Running line | | Non Running Line | | |
| | | | LH | RH | LH | RH | | LH | RH | LH | RH | | | | 1 in 18 | 1 in 9 | 1 in 18 | 1 in 9 | |
| **Summary Of Track Connections of BLT Track BetweenThiruvananthapuram to Kasaragod** | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | Thiruvananthapuram | 2 | 2 | 0 | 0 | 2 | 5 | 4 | 0 | 0 | 0 | 0 | **15** | 12 | 9 | 0 | 0 | **21** |
| 2 | 7 | Ernakulam | 2 | 2 | 0 | 0 | 2 | 5 | 5 | 0 | 0 | 0 | 0 | **16** | 12 | 10 | 0 | 0 | **22** |
| 3 | 11 | Thrissur | 2 | 2 | 0 | 0 | 2 | 4 | 4 | 0 | 0 | 0 | 0 | **14** | 12 | 8 | 0 | 0 | **20** |
| 4 | 13 | Kozhikode ( On UG) | 2 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | **6** | 12 | 0 | 0 | 0 | **12** |
| **Total** | | | **8** | **8** | **0** | **0** | **8** | **14** | **13** | **0** | **0** | **0** | **0** | **51** | **48** | **27** | **0** | **0** | **75** |
| **Summary Of Track Connections of Ballasted Track BetweenThiruvananthapuram to Kasaragod** | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | Thiruvananthapuram Stabling Lines | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | **4** | 0 | 0 | 0 | 4 | **4** |
| 2 | 2 | Thiruvananthapuram RORO(Kazhakkoottam) | 0 | 0 | 1 | 1 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | **8** | 4 | 4 | 0 | 2 | **10** |
| 3 | 3 | Kollam | 4 | 3 | 1 | 1 | 1 | 11 | 14 | 0 | 0 | 0 | 0 | **35** | 15 | 11 | 0 | 14 | **40** |
| 4 | 4 | Kollam-Depot | 0 | 0 | 0 | 0 | 0 | 21 | 20 | 0 | 0 | 10 | 1 | **52** | 0 | 1 | 0 | 54 | **55** |
| 5 | 5 | Chengannur | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | **12** | 12 | 4 | 0 | 0 | **16** |
| 6 | 6 | Kottayam | 2 | 2 | 1 | 1 | 1 | 4 | 4 | 0 | 0 | 0 | 0 | **15** | 12 | 6 | 0 | 2 | **20** |
| 7 | 8 | Ernakulam RORO (At Pazhanganad) | 0 | 0 | 1 | 1 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | **10** | 4 | 6 | 0 | 2 | **12** |
| 8 | 9 | Kochi Airport | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | 0 | 0 | 0 | 0 | **0** |
| 9 | 10 | Thrissur - RORO(Muriyad) | 0 | 0 | 0 | 0 | 2 | 14 | 6 | 0 | 0 | 0 | 0 | **22** | 8 | 8 | 0 | 12 | **28** |
| 10 | 12 | Tirur | 2 | 2 | 2 | 2 | 0 | 3 | 4 | 0 | 0 | 0 | 0 | **15** | 12 | 6 | 0 | 1 | **19** |
| 11 | 14 | Kozhikode - RORO(At West Hill) | 0 | 0 | 2 | 2 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | **12** | 8 | 6 | 0 | 2 | **16** |

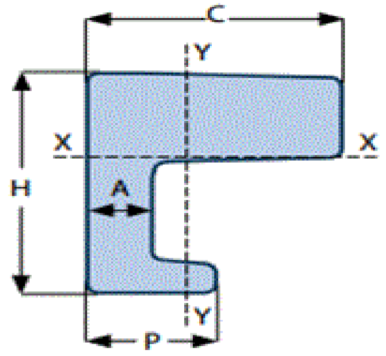
| S.No. | Station No. | Station Name | 1 in 18 | | | | | 1 in 9 | | | | | | Grant Total | Total Nos of Turnouts | | | | Grant Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 in 18 Turn Out | | 1 in 18 Cross over | | 1 in 18 Scissors cross over | 1 in 9 Turn out | | 1 in 9 Cross over | | 1 in 9 Symmetrical split | 1 in 9 Scissors cross over | | Running line | | Non Running Line | | |
| | | | LH | RH | LH | RH | | LH | RH | LH | RH | | | | 1 in 18 | 1 in 9 | 1 in 18 | 1 in 9 | |
| 12 | 15 | Kannur | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **5** | 8 | 0 | 0 | 0 | **8** |
| 13 | 16 | Kannur RORO | 0 | 0 | 1 | 2 | 0 | 12 | 7 | 0 | 0 | 0 | 0 | **22** | 6 | 6 | 0 | 13 | **25** |
| 14 | 17 | Kasaragod | 2 | 2 | 0 | 1 | 1 | 5 | 5 | 0 | 0 | 0 | 0 | **16** | 10 | 10 | 0 | 0 | **20** |
| 15 | 18 | Kasaragod RORO | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 0 | 0 | **5** | 0 | 0 | 0 | 7 | **7** |
| 16 | 19 | Kasaragod-Depot | 0 | 0 | 0 | 0 | 0 | 9 | 10 | 1 | 2 | 5 | 0 | **27** | 0 | 0 | 0 | 30 | **30** |
| **Total** | | | **14** | **13** | **11** | **13** | **6** | **94** | **88** | **2** | **3** | **15** | **1** | **260** | **99** | **68** | **0** | **143** | **310** |
| **Grant Total Nos.** | | | **22** | **21** | **11** | **13** | **14** | **108** | **101** | **2** | **3** | **15** | **1** | **311** | **147** | **95** | **0** | **143** | **385** |

#### 8.7.2.9 Specification for the Check Rails

No sharp curve requiring provision of check rails has been designed on the mainline of the SilverLine corridor except at points and crossings. Check rails if required shall satisfy the following criteria.

- All curves of radius sharper than 300m and locations opposite to crossings in turnouts on either side are to be provided with check rails.
- The check rails provided are of profile 33C1 or similar in accordance with EN standard 13674/3 of grade R 260 steel
- The check rail section shall be 33C1 or similar without any direct connection with running rails.
- Check rails shall have the facility for the adjustment of check rail clearances up-to 10mm over and above the initial designed clearance.
- Each check rail end shall be flared by machining to have minimum clearance of 62mm at end.
- The check rail connections in turnouts shall be through specially designed bearing plates / brackets.
- All the check rails shall be higher by 25mm above running rails. The lengths and positions of the check rail in diamond crossings shall provide safety and be compatible with the overall track layout.
- The check rails are provided on special brackets with the provision for adjusting the clearance between 60 to 70mm for curves and clearance opposite to crossings to be decided at the time of execution.
- The two types of check rail brackets used are of dip galvanized. The brackets are designed to maintain the height of the top of check rail w.r.t top of running rail as 25 mm.
- Flaring has been provided on either ends of the check rail for smooth entry and exit of the wheels. The clearances are to be checked by special clearance measuring gauges at the time of checking of curves and correct clearances are to be ensured by providing shims of 2,3,5 mm.
- The inside face of the check rail shall be greased once in a fortnight.

- A sketch showing the check rail and its physical properties are shown in **Figure below.**




| S.No | Description | Value |
|---|---|---|
| 1 | Section weight kg/m | 32.99 |
| 2 | Rail height mm (H) | 92.81 |
| 3 | Head width mm (C) | 80.00 |
| 4 | Web thickness mm (A) | 20.00 |
| 5 | Foot width mm (P) | 40.00 |

**Figure 8-53: Sketch showing the check rail and its physical properties.**

## 8.8 TRACK GEOMETRY:

Track geometry is very important for the running behavior of the vehicles. Hence in this section track Geometry will be discussed in detail. Following are the items which are discussed in detail **;**

1. Gauge
2. Track centers
3. Ruling gradient
4. Grade Compensation on Curves
5. Curves (a) Minimum radius of Horizontal Curve for Design Speed
6. Vertical curve
7. Cant & Equilibrium Cant
8. Cant Deficiency
9. Cant Excess
10. Track Structure
11. Speed Potential and axle load

*Note: Components like curves, vertical curves and cant are covered in Chapter 6 so not repeated here.*

### 8.8.1 Gauge:-

Standard Gauge (1435mm) has been selected for the project. Govt of Kerala took approval of this project as a stand-alone project where new technologies can be tried in

the interest of the country (Railway Board's letter No. 2018/ Infra/12/33 dated 16.10.18). Thiruvananthapuram- Kasaragod project plans to operate at 200kmph .

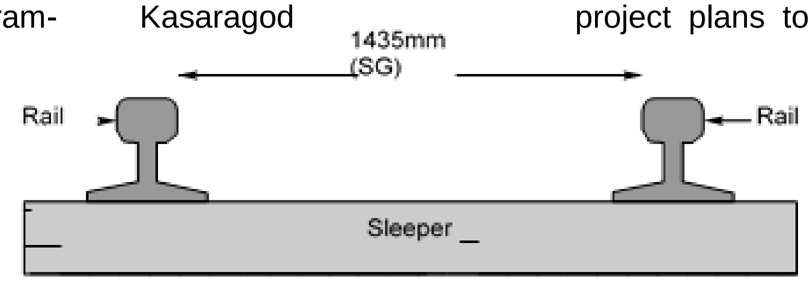



**Figure 8-54: Standard Gauge Track**

Standard Gauge has been preferred for the project over the broad gauge as SG is a proven technology all over the world for high speed operations for reasons like SG trains can obtain higher speeds in sharper curves and steeper grades due to their better stability, coaches are lighter, structural systems are simpler, land width required is less even if marginally, large number of technology and product sources are available and adaptation of the same is much easier and faster. With 3.2m-3.4m wide bodied coaches available in SG, passenger carrying capacities are also equal to BG with lesser cost of the project. Moreover, the SG is suitable for the terrain like Kerala due to requirement of sharper curves.

The gauges used in various countries worldwide are furnished in **Table 8-11.**

**Table 8-11: Gauges used for world's High-Speed Rails**

| Guages used for High-Speed Rails | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sl No | Railway lines | | | | | | | |
| | Type | Shinkansen | | TGV lines | | NBS (ICE) | AVE line | Direttissima |
| | Country | Japan | Taiwan | France | Korea | Germany | Spain | Italy |
| 1 | Gauge (mm) | 1,435 | 1,435 | 1,435 | 1,435 | 1,435 | 1,435 | 1,435 |

In existing systems of BG in IR, high speed operations have not been found feasible as existing technologies are not adequate for such speeds and track and system designs available are not supporting such speeds. International funding agencies require use of proven systems (at least for 5 years) for their acceptance.

There are also added advantages such as developing expertise in high speed technologies in SG as this will help India to take leadership in such a cutting technology area and export coaches and other systems to other countries in future.

The dynamic Gauge works to 1507 mm being the Rails Chosen is 60 Kg with head width 72 mm (i.e. 1435+72=1507 mm). The gauge may be measured at 14.3 mm below the top of rails being the head rounding off is 14.3 mm radius to suit the rolling stock wheels route radius.

### 8.8.2 Track Centre:-

Track center distance for SilverLine project is kept as 4.5m. The reasons are discussed hereunder;

Spacing between the lines is important for semi high-speed lines because when two trains pass each other, the speed difference can be very high. If two trains are too close to each other, there is burst of air pressure when they first pass and then a drop of pressure between the carriages. Although this is not enough to push the trains off the track, repeated stress on the windows cause fatigue, which may result in breakage of window glasses. Wider spacing between tracks however results in higher cost of the structures. Hence a suitable spacing need to be decided considering both requirements.

The distance between track centers adopted by some of the high-speed networks using standard gauge worldwide is given in **Table 8-12** for ready reference.

.

**Table 8-12: Worldwide Track Centers for high speed rail projects**

| Sl. No. | Country | Track Centres |
|---|---|---|
| 1 | France | 4.20 m |
| 2 | Germany | 4.50 m |
| 3 | Italy | 4.50 m |
| 4 | Spain | 4.30 m |
| 5 | Belgium | 4.20 m |
| 6 | Japan | 4.50 m |
| 7 | Shinkansen | 4.50 m |

**Basic Calculation for track centre distance:-**

a) On Static condition for the Sharpest curve with radius of 650 m on Mainline:-

- Parameters considered for working out centre clearance on curves are:-

| | | | |
|---|---|---|---|
| Gauge | = | 1435 mm | |
| Dynamic Gauge(G) | = | 1435+72 | = 1507mm |
| Buffer Length | = | 0.80 m | |
| Coach length | = | 25.00 m | |
| Height of coach (H) | = | 4.50m | |
| Length of coach excluding buffer lengths (L) | = | 25 - (2*0.80) =23.40 m | |
| Width of coach (W) | = | 3.40 m | |
| C/C of Bogies of Coach (C) | = | 19.0m (max:) &17.0m Min: | |
| Minimum Radius | = | 650.0 m on main lines. | |

- Extra Clearances for Mainlines:-

**Figure below** shows the clearances under critical movement.

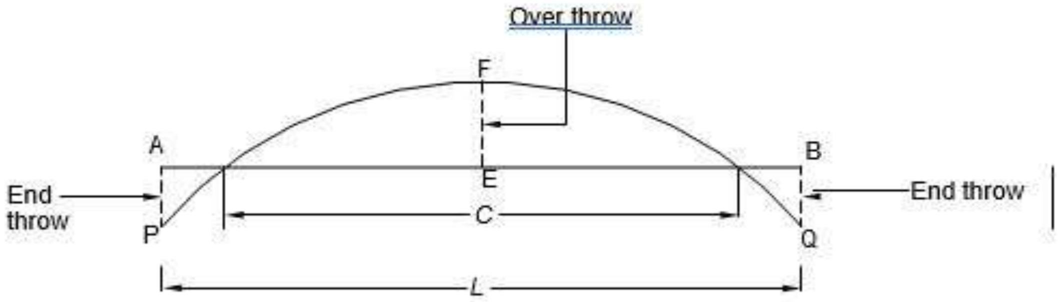



**Figure 8-55: Extra Clearances for MainLines**

| | | |
|---|---|---|
| Overthrow | = | 1000*C*C/8/650 |
| | = | 1000X19.0x19.0/8/650 = **69.4** mm |
| End throw | = | 1000*(L*L-C*C)/8/650 |
| | = | 1000x(23.8X23.8-17.0x17.0)/8/650 |
| | = | **53.35mm** |
| Effect of lean due to SE | = | H*SE/G |
| | = | 4.5*160/1.507 = **477.77** mm. |
| Sway assumed 1/4$^{th}$ of sway | = | ¼ * 477.77 = **119.44** mm. |

Therefore, Extra Clearance required for 650m Radius

| | | |
|---|---|---|
| | = | 69.40+53.35+2*119.44 |
| | = | 361.63 or say **362mm** |

| | | |
|---|---|---|
| Minimum additional clearance required between coaches on straight tracks | = | 300 mm. |
| Therefore, Minimum track centers | = | 3400+362+300 |
| | = | **4062 mm** |
| **Say** | **=** | **4.062 m** |

b) On Dynamic condition for sharpest curve with radius of 650 m on Mainline:-

| | | |
|---|---|---|
| From Kinematic Envelop | = | 1950 mm |
| Overthrow | = | 69.40 mm |
| End throw | = | 53.35 mm |
| Minimum additional clearance required | | |
| In straight tracks | = | 300 mm |
| Therefore, Track Centers required | = | 2 x 1950 + 69.40 + 53.35 + 300 |
| | = | **4322 mm Or say 4.32 m** |

**Considering the above calculations, the minimum track centers required for mainline is only 4.32m.**

c) Basic Calculation for the arriving at the Track Centres for 190 m Radius for Depot lines:-

On Static Condition -

| | | |
|---|---|---|
| Gauge | = | 1435 mm |
| Dynamic Gauge(G) | = | 1435+72 = 1507mm |
| Buffer Length | = | 0.80 m |
| Coach length | = | 25.00 m |
| Height of coach (H) | = | 4.50m |
| Length of coach excluding buffer lengths(L) | = | 25- (2*0.80) = 23.40 m |
| Width of coach (W) | = | 3.40 m |
| C to C of Bogies of Coach (C) | = | 19m (max:) & 17m Min: |
| Minimum Radius | = | 190m |

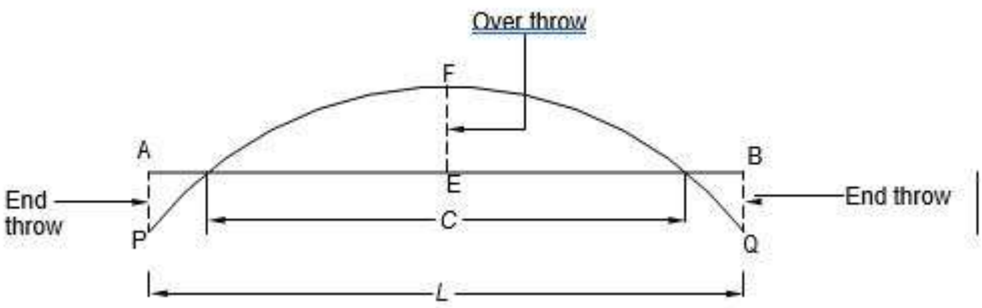



**Figure 8-56: Extra Clearances for Depot Lines**

| | | |
|---|---|---|
| Overthrow | = | 1000*C*C/8/R |
| | = | 1000X19.0x19.0/8/190 |
| | = | **237.50 mm** |

End throw = 1000*(L*L-C*C)/8/190
= 1000x(23.8X23.8-17.0x17.0)/8/190
= **170.10 mm**

Effect of lean due to SE = 0

Sway = 0

Therefor Extra clearance required = 237.5+170.1
= 407.60 mm

Minimum clearance required between coaches= 300 mm.

Therefore, Minimum track centers = 3400+407.6+300
= **4107.60 mm**
**= 4.11 m**

d) Based on Shinkansen Railway standard:-

The kinetic envelope represents maximum displacement of the outline from track center line and the rail level. This envelope is comprising of -

a) Rolling stock profile

b)Track vehicle tolerance

c) Allowance for curvature and super elevation

d) Dynamic effect

The kinetic envelope of the train generally shall be calculated in accordance with UIC505 series. The structure gauge is derived from the kinetic envelope adding the required allowance over the kinetic envelope. For the SilverLine project the structure gauge and track spacing may be proposed based on the shinkansen static profile and the corresponding structure gauge. However at the time of procurement of the train set kinematic envelope and structure gauge corresponding to Rolling stock profile etc. shall be verified in terms of the provisions in UIC505 and compatibility be confirmed.

As per approved model specifications Para III-11. related to article 22 (distance between track centers) (2) ① the distance between track centers at a tangent line of the main track (to be limited to the track for a train travelling at 300km/h or less speed) shall not be less than the maximum width of the basic rolling stock gauge plus **800mm** (600mm for the sections where the train will travel at 160km/h or less). The value shall be increased where necessary for work or the like. This works out 4200 mm (3400 + 800). In straight tracks, Shinkansen has provided 4.50 m track centres including movement clearance on curves for speed up to 300 kmph.

**Recommended Track Centres**

In view of the above calculations and based on the international experience, a track centre spacing of **4.5 m** has been considered suitable for SilverLine project. This is suitable both for tangent track as well as for curved tracks as **extra clearances up to 190 m radius**

**have been provided for.** The track center distance may be increased suitably on sharp parallel tracks, in non-running lines Washing aprons and Work Shop lines. The track spacing adopted is 7m for Washing lines and 8m for Workshop lines. This all may be reviewed by Track DDC at the time of execution.

### 8.8.3 Grade Compensation On Curves:-

Ruling gradient in the project is 1 in 60 (16.7‰). Grade compensation for curves will be at the rate of 0.4‰ per degree of curvature. Curves provide extra resistance for the movement of trains on Curves with Gradients. As a result, gradients are to be compensated / reduced depending upon the Sharpness of curves at the locations.

Being the maximum grade provided is 16‰ in the curved portion of 1860m radius (0.945 degree), the ruling gradient works out to 16+(0.945 x 0.4) = 16.378 as against 16.7‰ ruling gradient permitted. Therefore, no curvature is required to be compensated in the SilverLine.

### 8.8.4 Horizontal Curves:-

Curves are introduced on a railway track to bypass obstacles, to provide longer and easily traversed gradients, and to pass a railway line through obligatory or desirable locations. Horizontal curves are provided when a change in the direction of the track is required and vertical curves are provided at points where two gradients meet or where a gradient meets level ground.

Standard features of a typical curve showing all basic components is shown in **Figure below**;

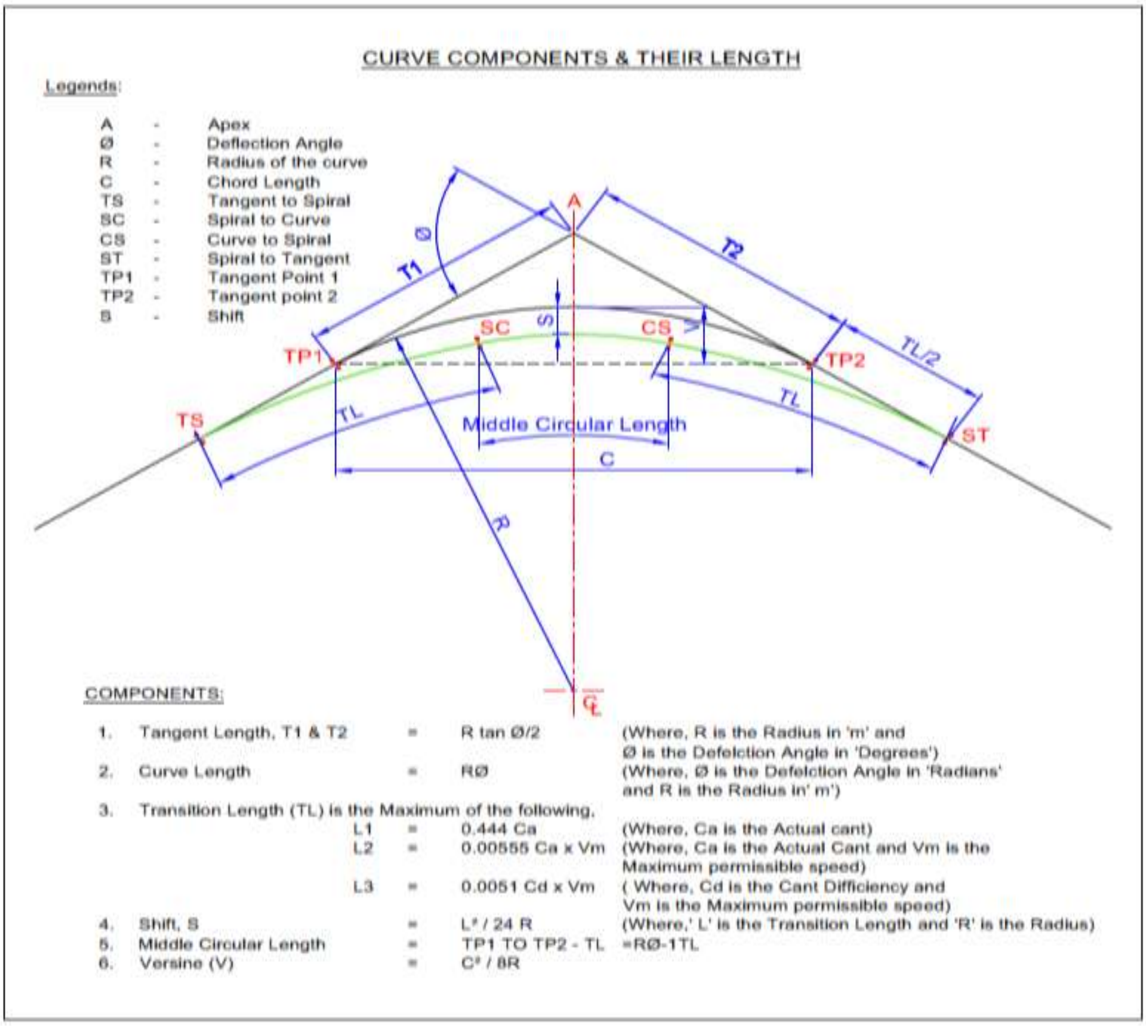



**Figure 8-57: Standard features of a typical curve.**

### Degree of a curve and minimum radius adopted for 200Kmph speed:-

- **Degree of Curvature -**

A curve is defined either by its radius or by its degree. The degree of a curve (*D*) is the angle subtended at its center by a 30.5m chord.

The value of the degree of the curve can be determined as indicated below.

Circumference of a circle = 2π *R*

Angle subtended at the center by a circle with this circumference = 360° Angle subtended at the center by a 30.50 m chord, or degree of curve

Say, R= 360/2πx30.5 = 1748.50m

= **1750 m** **(**Where R is in meters)

In cases where the radius is very large, the arc of a circle is almost equal to the chord connecting the two ends of the arc. The degree of the curve is thus given by the following formulae

$D = 1750/R$ (when $R$ is in meters)

A 2° curve, therefore, has a radius of 1750/2 = **875 m**

Length of Curve is given by the formula

L= R θ (where R is Radius in meters and θ is the deflection angle in Radians)

- **Minimum Radius adopted for the project to get 200Kmph speed:-**

The minimum radius is given by the formula for attaining the operational speed of 200 Kmph is given by

$$R = 11.8 \times V^2 / (Cm + Cd)$$

Where R: Minimum Radius of curve (m), Cm: Maximum cant (mm), Cd: Deficient cant (mm), V: Design speed (km/h)

Therefore, R Minimum = 11.8*200*200/ (160+100)

= 1815.4 or

Say **1850m** (**by rounding off to the nearest multiple of 50)**

Accordingly, Minimum Radius is considered as 1850m for alignment design of SilverLine alignment.

However, to negotiate habitated city / town areas and to locate stations at appropriate palce, the radius up to 650 m is permitted within 2km in station approaches where the trains accelerate or decelerate. Hence, it will not affect the running time.

- The radii adopted in Shinkansen Railway are furnished in **Table 8-13**.

**Table 8-13: Horizontal curve radius and speed limit for the Shinkansen**

| Horizontal Curve Radius | Speed Limit (maximum) | Actual set Cant | Cant Deficiency |
|---|---|---|---|
| More than 3,500 m | 300 km/h | 200 mm | 110 mm |
| More than 3,000 m | 270 km/h | 200 mm | 110 mm |
| More than 2,500 m | 255 km/h | 200 mm | 110 mm |
| More than 2,200 m | 230 km/h | 200 mm | 90 mm |
| More than 2,000 m | 220 km/h | 200 mm | 90 mm |
| More than 1,800 m | 210 km/h | 200 mm | 90 mm |
| More than 1,500 m | 190 km/h | 200 mm | 90 mm |
| More than 1,200 m | 170 km/h | 200 mm | 90 mm |

| | | | |
|---|---|---|---|
| More than 1,000 m | 155 km/h | 200 mm | 90 mm |
| More than 900 m | 145 km/h | 200 mm | 90 mm |
| More than 800 m | 140 km/h | 200 mm | 90 mm |
| More than 700 m | 130 km/h | 200 mm | 90 mm |
| More than 600 m | 120 km/h | 200 mm | 90 mm |
| More than 500 m | 110 km/h | 200 mm | 90 mm |
| More than 400 m | 95 km/h | 200 mm | 90 mm |

*Note:- More about the horizontal curves and total nos of curves are discussed in Chapter 6 of this DPR so not repeated here.*

### 8.8.5 Vertical Curve Design:-

An angle is formed at the point where two different gradients meet, forming a summit or a sag as explained in **Figure below**. The angle formed at the point of contact of the gradients is smoothened by providing a curve called the vertical curve in the vertical plane. In the absence of a vertical curve, vehicles are likely to have a rough running on the track. Besides this, a change in the gradient may also cause bunching of vehicles in the sags and a variation in the tension of couplings in the summits, resulting in train parting and an uncomfortable ride. To avoid these ill effects, the change in gradient is smoothened by providing a vertical curve. A rising gradient is normally considered **positive (+ve)** and a falling gradient is considered **negative (-ve).**

A vertical curve is normally designed as a circular curve. The circular profile ensures a uniform rate of change of gradient, which controls the rotational acceleration.

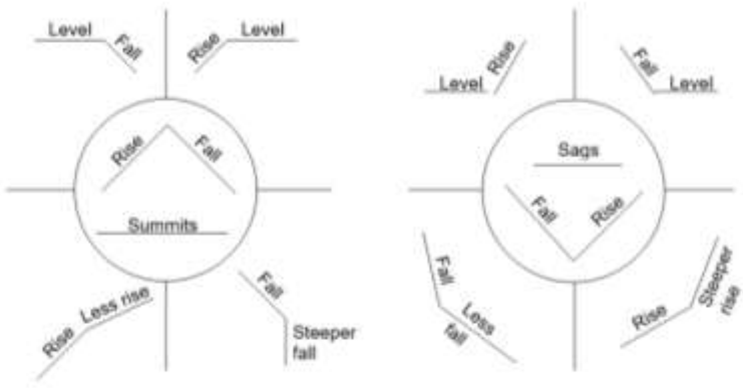



**Figure 8-58: Summits and sags in vertical angles in different planes**

*Note: - More about the vertical curves and total nos of curves and gradients with list are discussed in Chapter 6 of this DPR so not repeated here.*

### 8.8.6 Rail Cant:-

Rail cant and conicity of wheel profile to be followed is prescribed as 1 in 20 in the project. This is required to distribute contact stresses and prevent shunting phenomenon on running.

### 8.8.7 Ballast Depots:-

For operation and maintenance of the SilverLine project, the track stone ballast in desired quantities is to be procured and stacked as per standard procedures. Ballast depots, in this purpose, are identified at Kollam, Kottayam, Thrissur (Muriyad) and Kozhikode (West Hill) which are at about 80 to 120 km inter distances and the same may be reviewed during implementation stage as per requirements.

**1) Ballast Depot at Kollam:-**
The location of the ballast depot is just outside the Kollam maintenance depot. The tentative area allocated for ballast depot is 2 Ha. It is planned that this depot to serve ballast between Thiruvananthapuram and Chengannur.

**2. Ballast Depot at Kottayam:-**
The location of the ballast depot is with area proposed at Kottayam. The tentative area allocated for ballast depot is 2 Ha. It is planned that this depot to serve ballast between Chengannur and Ernakulam.

**3. Ballast Depot Thrissur:-**
The location of the ballast depot is with area proposed at Thrissur. The tentative area allocated for ballast depot is 2 Ha. It is planned that this depot to serve ballast between Ernakulam and Tirur.

**4. Ballast Depot Kozhikode:-**
The location of the ballast depot is with area proposed at Kozhikode RORO yard (West Hill). The tentative area allocated for ballast depot is 2 Ha. It is planned that this depot to serve ballast between Tirur and Kasaragod.

### 8.8.8 Track Machine Sidings:-

Provision has been made for providing Track Machine sidings at Kollam, Thrissur, and Kannur to enhance prompt maintenance of track and structures by moving machines, materials and manpower from the siding locations which are located about 200 km inter distances.

## 1. Track Machine siding at Kollam:-

First track Machine siding is planned to be located at Kollam near the Depot to serve the section from Thiruvananthapuram to Ernakulam as shown in the **Figure below**

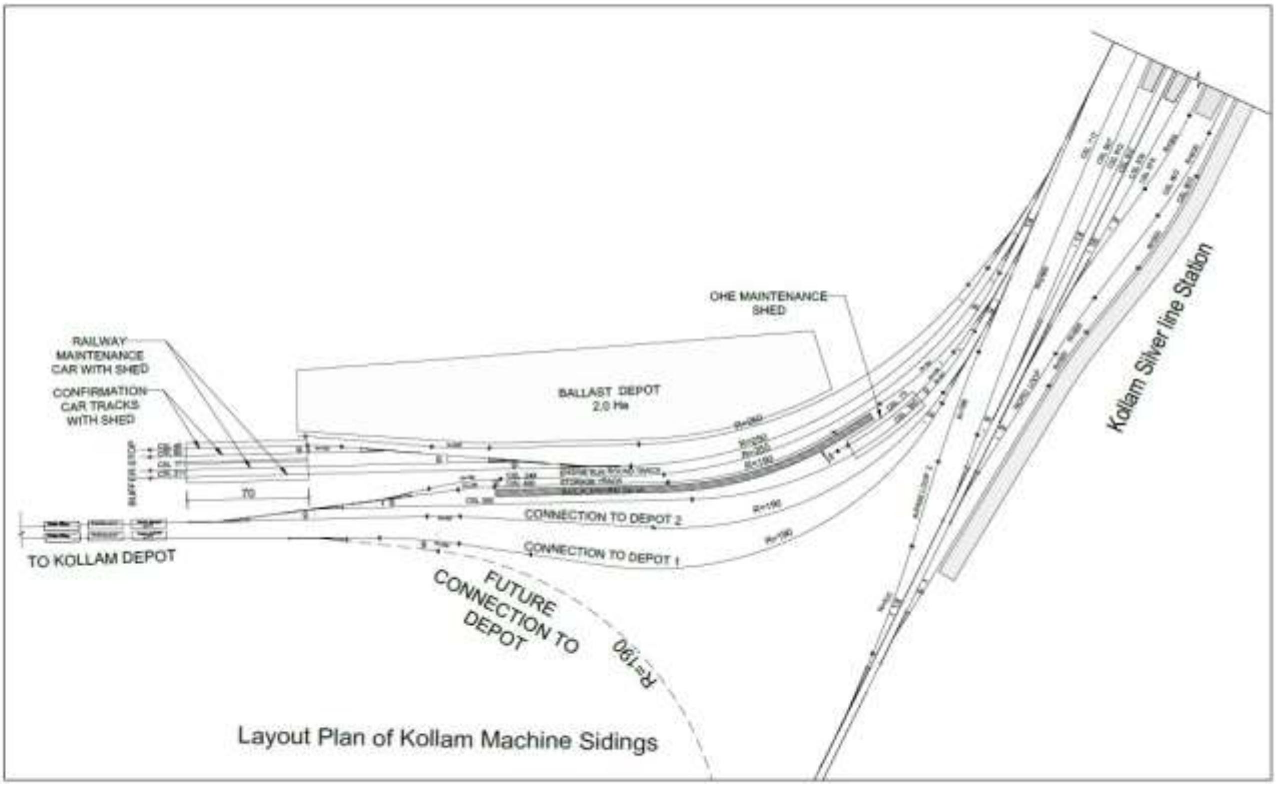



**Figure 8-59: A sketch showing the Machine Siding proposed at Kollam Depot**

## 2. Track Machine Siding At Thrissur:-

Track Machines siding planned to be located at Thrissur will serve from Thrissur to Ernakulam and Thrissur to Kozhikode. The Machine siding is proposed along with RORO

loops. A sketch showing the Machine Siding proposed at Thrissur is shown as **Figure below**

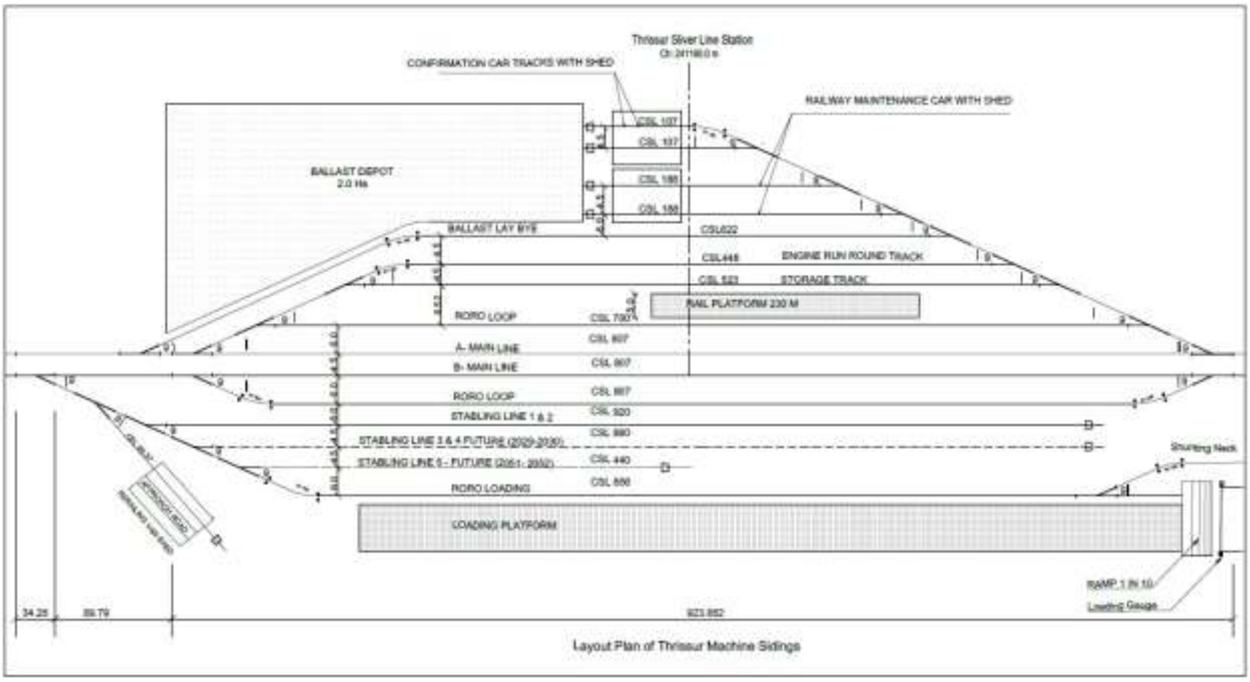



**Figure 8-60: A sketch showing the Machine Siding proposed at Thrissur RORO**

## 3. Track Machine Siding At Kannur:-

Track Machine siding proposed to be located at Kannur will serve from Kannur to Kozhikode and Kannur to Kasaragod. Kannur Machine siding is proposed with RORO loops as shown in **Figure below**

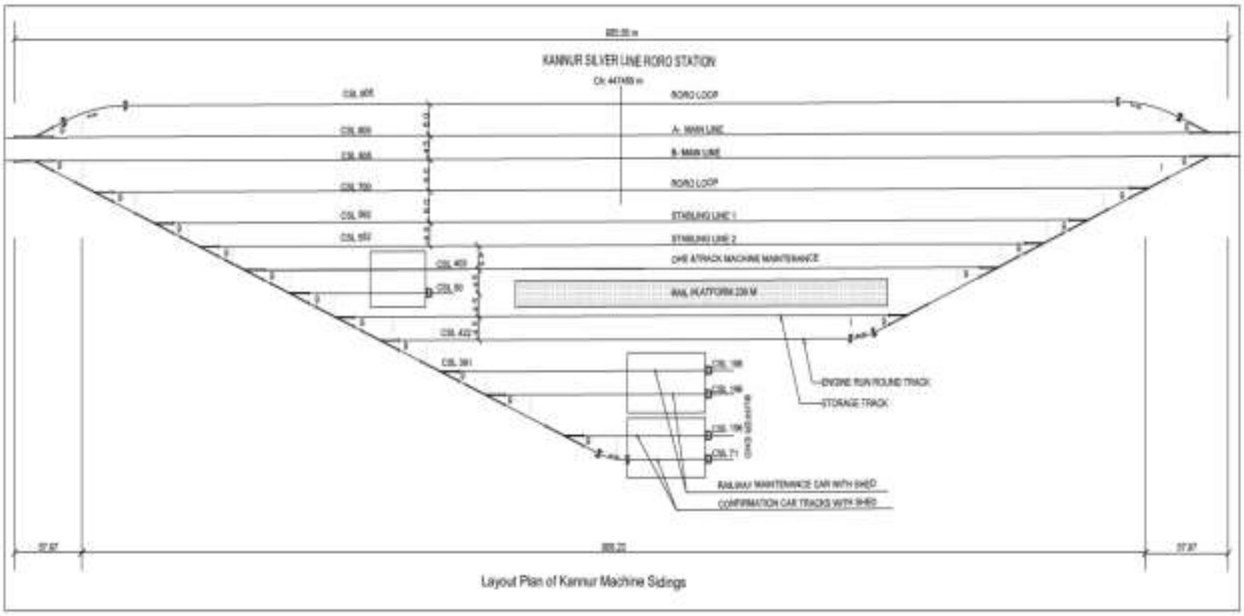



**Figure 8-61: A sketch showing the Machine Siding proposed at Kannur**

### 8.5.9 Track Laying and Construction:-

There are three prevalent methods of construction of railway tracks worldwide as elaborated hereunder;

1. Telescopic Method
2. Tramline Method
3. Mechanical Method

The most suitable method is to be adopted for laying of ballast less and ballasted tracks as per site suitability and economic criteria. A decision is required to be taken at the time of tendering/execution. Methods are described as under;

**1) Telescopic Method of Construction of Railway Track:-**

In this method, rails, sleepers and fastenings are unloaded from the material train as close to the rail head as possible. The sleepers are carried by carts or men along the adjoining service road and spread on the ballast. The rails are then carried on pairs to the end of the last pair of connected rails and linked.

As to carry the rails manually over a long distance is a tedious job, so certain carriers called Anderson rail carriers are used to carry rails to the ends of the rail head. It can also take rails up to a head last pair linked with the help of temporary track consisting of 3" x 3" angle irons of the same length as rails and fastened to the sleepers.

**2) Tramline Method for Railway Track Construction**

This method is used where tram carrier is installed for carrying earthwork or in rainy season due to difficulty in movement of cart. Some tramline is established on with a gauge of 761 mm. The basic difference between this and telescopic method lies in the conveyance and spreading of the sleepers.

The track can be assembled at more than one location simultaneously, which is the main advantage of this method. Sometimes an additional track is laid on the side of existing track in this method.

**3) Mechanical Method Railway Track Construction**

This method is extensively used in Britain and America by using special track laying machine. There are two types of machines available. In first type of machine, the track material carried by the material train is delivered at the rail head and laid in the required position by means of projecting arm or mounted on the truck nearest to the rail head. The material train moves forward on the assembled track and operation is repeated.

In the second type of machines a long-cantilevered arm projecting beyond the wagon on which it is fitted. A panel of assembled track consists of pair of rails with appropriate number of sleepers on the ballast layer. This panel is conveyed by special trolley running over the wagons of material train to the jibs. It is lowered by the jib in the required position

and connected to the previous panel. The track laying machine then moves forward, and operation is repeated.

## 8.9 TRACK SUPPORTING STRUCTURE – EMBANKMENT:

### 8.9.1 Embankment Profile:-

Embankment or bank is made of earthen material that is placed and compacted for the purpose of raising the formation of a railway line to the required level above the level of the existing surrounding ground surface. The location where the rail level is higher than the natural ground level by 742mm (the total height of Rail 172mm+ pad 10mm+sleeper 210mm at rail seat+ 350mm ballast cushion at rail seat), the embankment is considered at zero height. The general components of an embankment are shown in **Figure below**;

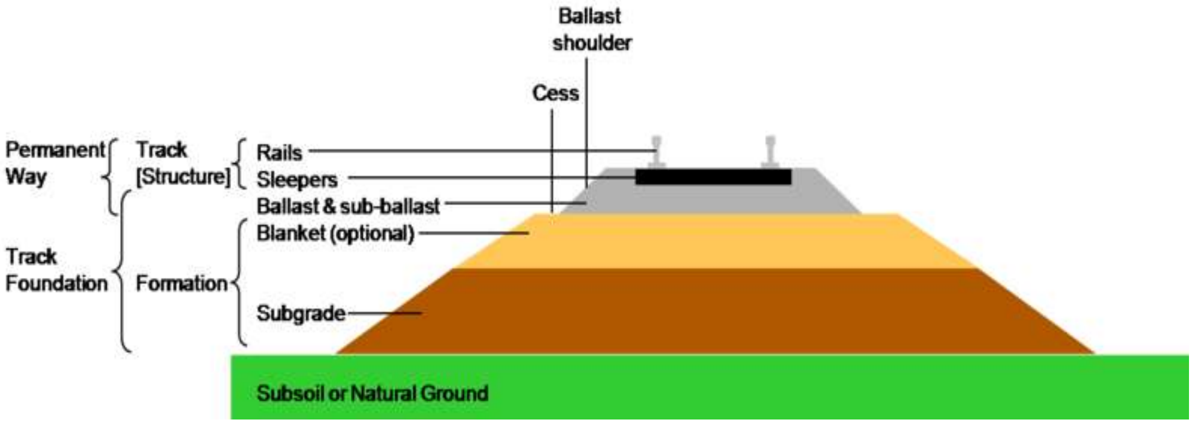



**Figure 8-62: Components of embankment**

A schematic cross section of Embankment based on UIC 719 R suitable for SilverLine track is depicted in **Figure below**;

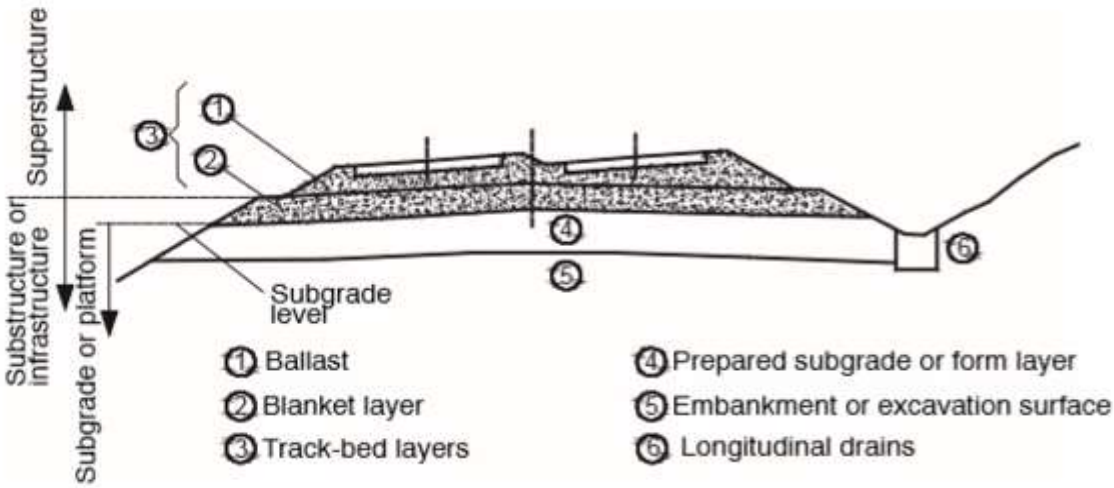



**Figure 8-63: Schematic Cross section of Embankment for two tracks**

*Note: There is a prevailing practice in some of the countries which consider the blanket layer in the superstructure.*

For construction of embankment, reference has been given to “Guidelines and Specifications for Design of Formation for Heavy Axle load” vide RDSO/2007/GE.0014 also.

### 8.9.2 General Terminology for track supporting structures

For easy understanding of the track supporting structures terminology, some of the commonly used terms with their specific meanings are given below;

1. Formation: In a general way, collectively refers to the layers comprising blanket, prepared subgrade and embankment fill.
2. Formation Top: Boundary (interface) between ballast and top of blanket or prepared subgrade (where blanket layer is not provided).
3. Track Foundation: Constitutes ballast, blanket, prepared subgrade and Embankment fill, which is placed / exist below track structure to transmit load to subsoil.
4. Cess: Portion at top of formation level, extending from toe of ballast to edge of formation.
5. Ballast: Crushed stones with desired specifications placed directly below the sleepers.
6. Sub-ballast: Sub-ballast is a layer of coarse-grained material provided between blanket/subgrade (where blanket is not provided) and ballast confined to width of ballast section only. However, it is desirable to provide adequate depth(adequate cushion) of clean and well-graded ballast to ensure required resilience, track modules and drainage and sub ballast in such a case is not necessary.

7. Blanket: Blanket is a layer of specified coarse, granular material of designed thickness provided over full width of formation between subgrade and ballast.
8. Prepared Subgrade: In case of two-layer system, it is provided over the subgrade and below the blanket layer with a view to economize the thickness of blanket layer.
9. Embankment Fill: It is that part of Embankment which is constructed with borrowed soil and compacted to the stipulated level.
10. Sub-grade: It is the upper part of Embankment fill/ cutting constructed by borrowed soil of suitable quality up to bottom of blanket/prepared subgrade. For Embankment, subgrade may be of borrowed soil whereas in cuttings it can be the naturally occurring soil of enough strength.
11. Cohesive Subgrade: Subgrade constructed with soils having cohesive behavior i.e., shear strength is predominantly derived from cohesion of the soil is termed as cohesive subgrade. Normally, soils having particles finer than 75 microns exceeding 12% exhibit cohesive behavior. As per IS classification, all fine-grained soils and GM, GM-GC, GC, SM, SM-SC & SC types of soils exhibit cohesive behavior.
12. Cohesionless Subgrade: Subgrade constructed with cohesion-less, coarse-grained soils i.e., shear strength is predominantly derived from internal friction of the soil are termed as cohesionless subgrade. Normally, soils having particles finer than 75 micron less than 5% exhibit cohesion-less behavior. As per IS Classification, GW, GP, SW & SP types of soils fall in this category.

    Other types of soils, which have soil particles finer than 75 microns between 5 to 12%, need detail study for ascertaining their behavior.

13. Dispersive Soil: Dispersive soils are those, which normally deflocculates when exposed to water of low salt content. Generally, dispersive soils are clays which are highly erosive, and Specifications for Railway Formation have high shrink and swell potential. These soils can be identified by Crumb, Double Hydrometer, Pin Hole and Chemical Tests.

14. Subsoil: The soil below natural ground level.

15. Weak/ Unstable Formation: It is yielding formation with continued settlement including slope failure, which require excessive maintenance efforts.

16. Shear Strength: Shear strength of soil is its ability to resist shearing at a shearing surface (plane) under direct stress (vertical pressure)

### 8.9.3 Subgrade failure mechanism - To be fought against:-

When the train passes over the track, subgrade is subjected to a certain cyclic stress. If this stress is greater than a particular stress level called threshold stress for the soil, ballast penetrates into the foundation soil progressively causing the subgrade failure. Penetrated ballast tends to store water percolating through the track surface. Under the train loads, mud pumping phenomenon is observed. Mud pumping of track is a phenomenon caused when bed soil is softened by the rainfall or ground water; the mud climb up though the void inside the ballast and pumped out on the ballast surface by a passing train load, this displaces the clay and fines present in subgrade soil and completely disrupts the drainage system causing further track deterioration.

The study team viewed to avoid this type of failure and hence attempts have been taken to bring forward various methods to protect against this and to develop better track bed (formation + Ballast) in the following descriptions.

### 8.9.4 Methodology for Study team to select the embankment sections:-

In Kerala State, there are variety of factors as the preconditions on the selection of structures in structure planning for safe construction. There are topographical undulations and geological variations including mountains, combination of hills and plains, varied land utilization in urban areas, outskirts, suburbs of cities and rural districts, intersections between railways and rivers/roads and longitudinal section. In the structure planning for Kerala Semi High-Speed Railways, Study team shall also pay attention to track structures, location of turnouts, and civil engineering structures supporting these facilities. Depending on the topological, geological and surrounding environmental conditions, engineering structures between stations are classified into earth structures (embankments and cuttings), viaduct, bridges and tunnels. Study team after due deliberations summarized the scope of application of embankments and other structures as follows;

The civil engineering structures along the corridor including earth structures (embankments and cuts) are considered and decided on the basis of economy and easiness of construction with safety during and after construction. However, the embankment structures tend to break the continuity of urbanity and disturb movement between citizens in the area. Furthermore, soft surface ground or flood prone areas are subjected to slope collapse and liquefaction of track bed due to settlement, heavy rains or earthquakes after commissioning or apprehended to pose other problems in upkeep and control. Therefore, Study team adopted the combinations of bank, cut, cut & fill, tunnel and viaducts.

The functions and material specifications of layers of formation are summarized below;

(*Soil Categories SQ1, SQ2 & SQ3 have been modified slightly from UIC practices to suit Indian conditions & BIS Classification system, as refered from RDSO GE 0014.* Hence, maximum reference has been given to the RDSO standard only. However, the high speed, axle load, sleeper length and spacing, and diameter of wheel,etc. of SilverLine has been accounted in deciding different aspects like formation layer thickness, etc. in the following paragraphs).

### 8.9.5 Blanketing:-

Blanketing is an important component of the formation as indicated in the **Figure above** and it is designed layer of specified coarse, granular material of designed thickness provided over full width of formation between subgrade and ballast.

- **Provision of blanket layer, its major functions and importance:-**

a) It reduces traffic-induced stresses to a tolerable limit (i.e. threshold stress) on the top of subgrade, thereby, prevents subgrade failures under adverse conditions of rainfall, drainage, track maintenance and traffic loadings.

b) Being well graded coarse-grained material with fines, it prevents penetration of ballast into the subgrade and prevents upward migration of fine particles from subgrade into the ballast under adverse conditions during service.

c) Its absence or inadequate thickness results in yielding formation and instability. This necessitates high maintenance inputs and increased cost of maintenance. If this not provided, speed restrictions may have to be imposed, which adversely affects the throughput of the traffic on corridor.

d) Its absence may result in bearing capacity and progressive shear failures of the subgrade soil, thereby endangering safety of running traffic.

e) This restricts plastic deformation of subgrade caused due to cyclic stresses induced by movement of trains.

f) It results in increased track modulus and thereby reduces the track deformations. Consequently, due to reduction in dynamic augment, stresses in rails as well as sleepers gets reduced.

g) This facilitates drainage of surface water also and reduces moisture variations in subgrade, thereby reducing track maintenance problems.

h) It prevents mud pumping by separating the ballast and subgrade soil. Thus, accumulation of excess pore water pressure in the soil mass is avoided which causes mud pumping.

i) It ensures that the induced stress in subgrade is kept below the threshold stress of subgrade soil.

j) It facilitates dissipation of excess pore water pressure developed in subgrade on account of cyclic loading and leads to increase in shear strength of subgrade soil.

k) It leads to enhanced performance of subgrade as subgrade can serve designed functions more efficiently and effectively if blanketing is done.

l) It obviates the need for formation rehabilitation work under running traffic at prohibitive costs since it is a challenging requirement of SilverLine.

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- **Blanketing Material:-**

The blanket material is produced by mechanical process by crushing the stones and/or by mixing, naturally available materials using suitable equipment/plants like pug mill, wet mix plant, crusher etc. However, if naturally available material conforms to the specifications, the same can also be used.

Blanket material produced in a plant should generally conform to following specifications:

a) It should be coarse, granular and well graded.

b) Skip graded material is not permitted.

c) Non -plastic fines (particles of size less than 75 micron) are limited maximum to 12%, whereas plastic fines are limited maximum to 5%.

d) The blanket material should have particle size distribution curve within one of the bands of enveloping curves shown in figure 8.66 or the percent passing of the material through each IS sieves should lie between the upper and lower limit of blanket material as given in the **Table 8-14.**

e) The material should be well graded with Cu & Cc as under:

Uniformity coefficient, Cu = D 60/D10 > 7

Coefficient of curvature, $C_C = \dfrac{D_{30}^2}{D_{60} x D_{10}}$ between 1 and 3

(f) Particle size distribution must follow one of the gradation ranges tabulated below.

**Table 8-14: The Gradation Ranges**

| Sl No | IS Sieve | Grade A | Grade B | Grade C |
|---|---|---|---|---|
| 1 | 40mm | 100 | 95-100 | 95-100 |
| 2 | 20mm | 100 | 93-100 | 80-100 |
| 3 | 10mm | 95-100 | 85-95 | 65-85 |
| 4 | 4.75mm | 92-99 | 70-92 | 43-70 |
| 5 | 2mm | 65-90 | 46-65 | 22-46 |
| 6 | 600 micron | 33-50 | 22-33 | 08-22 |
| 7 | 425 micron | 28-40 | 18-28 | 05-18 |
| 8 | 212 micron | 16-27 | 10-16 | 0-10 |
| 9 | 75 micron | 0-12 | 0-10 | 0-8 |

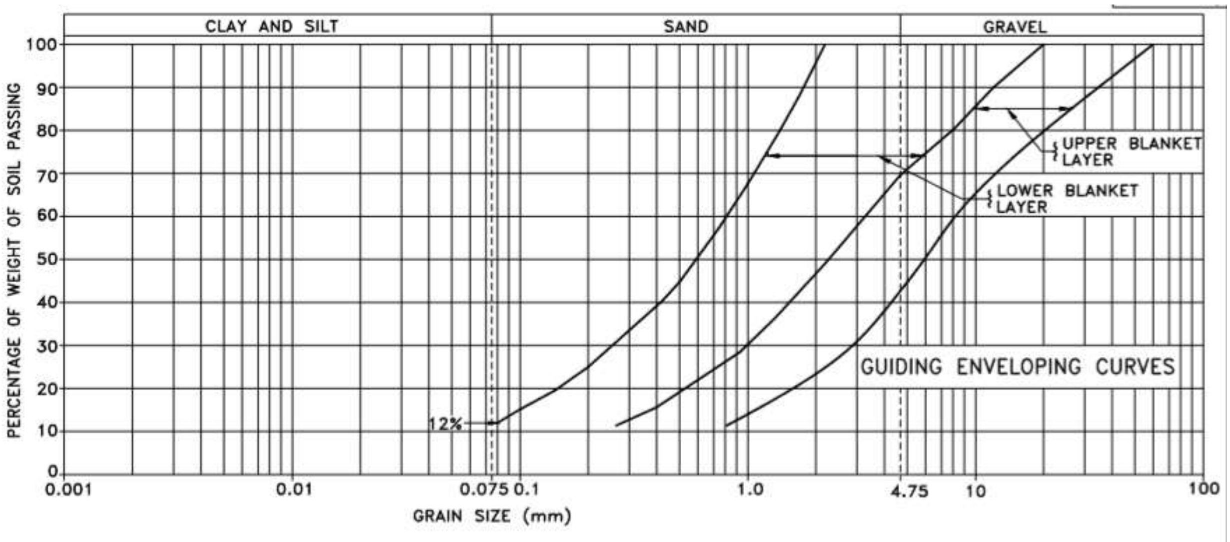



**Figure 8-64: Particl Size Distribution Curves**

- **Selection of Blanket Material:-**

Depending on the source of material, the blanket material can be categorized in the following categories:

a) Natural material
b) Machine manufactured material

- Crushed material
- Blended material

Suitable decision is to be taken during execution on the choice of material based on availability.

- **Depth of Blanket Layer:-**

Depth of blanket layer of specified material depends primarily on type of subgrade soil and axle load of the traffic.

Depth of blanket to be provided for the design axle load of 22.5 t for different types of subgrade soils (describing top one meter thickness) has been given as under. In case more than one type of soil exists in top one meter then soil requiring higher thickness of blanket will govern.

a) Following soils shall not need blanket-

- Rocky beds except those, which are very susceptible to weathering e.g. rocks consisting of shales and other soft rocks, which become muddy after coming into contact with water.
- Well graded Gravel (GW)
- Well graded Sand (SW)
- Soils conforming to specifications of blanket material.

b) Following soils shall need minimum 45cm thick Blanket-

- Poorly graded Gravel (GP) having Uniformity Coefficient more than 2.
- Poorly grade Sand (SP) having Uniformity Coefficient more than 2.
- Silty Gravel (GM)
- Silty Gravel – Clayey Gravel (GM – GC).

c) Following soils shall need minimum 60cm thick Blanket-

- Clayey Gravel (GC)
- Silty Sand (SM)
- Clayey Sand (SC)
- Clayey Silty sand (SM-SC)

Note: The thickness of blanket on above type of soils shall be increased to 1m, if the plasticity index exceeds 7.

d) Following types of soils shall need minimum 1m thick Blanket-

- Silt with low plasticity (ML)
- Silty clay of low plasticity (ML-CL)
- Clay of low plasticity (CL)
- Silt of medium plasticity (MI)

- Clay of medium plasticity (CI)
- Rocks which are very susceptible to weathering

Use of geo-synthetics can be considered at places where it is economical to use in combination with blanket material as it reduces the requirement of thickness of blanket. It may be particularly useful in cases of rehabilitation of existing unstable formation and in new construction where availability of blanket material is scarce.

- **Blanket thickness Based on UIC Two-layer system:-**

The Railway formation may be constructed with Single Blanket Layer System or Two Layer System based on availability of local soils/materials and on economic considerations as per recommendation of Design Consultant. The specifications and thickness of Blanket layer, Prepared subgrade, Top layer (Subgrade), Lower fill and Sub-Soil are tabulated for single blanket layer system and Two-layer system as per design to suit the Axle load requirements. Recommended minimum thickness of blanket for axle load of 22.5T is given in the **Table 8-15** below for general idea for a two layer system.

**Table 8-15: UIC Based Two-layer system of blanketing on Track Formation**

| Soil-quality category in subgrade | Topsoil Formation (prepared subgrade) | | Recommended minimum thickness (mm) of Blanket for axle load 22.5T |
|---|---|---|---|
| | Quality | Thickness(mm) | |
| SQ1 | SQ2 | 500 | 200 |
| SQ1 | SQ3 | 500 | 100 |
| SQ2 | SQ2 | - | 200 |
| SQ2 | SQ3 | 350 | 100 |
| SQ3 | SQ3 | - | 100 |

*(Ref: Report no. RDSO/ 2007/ GE: 0014 & UIC 719 R- 2008 page 16/table 6 and page 36)*

Description of the soil as per Report No. RDSO/2007/GE: 0014 is given in the **Table 8-16** for ready reference;

**Table 8-16: Description of Soil Quality Class as per IS classification**

| Soil Quality | Description with respect to fine particles (size less than 75 micron) | Soils as per IS classification conforming to Referred Soil Quality |
|---|---|---|
| SQ1 | Soils containing fines > 50% | CL, ML, CL-ML, CI, MI, CH, MH |
| SQ2 | Soils containing fines from 12% to 50% | GM, GC, SM, SC |
| SQ3 | Soils containing fines less than 12% | GW, GP, SW, SP, GW-GM, GW-GC, SW-SM, GP-GM, GP-GC, SP-SM, SP-SC |

- **General notes:-**

1. For highspeed lines a bearing capacity class of good subgrade should be considered.
2. Thickness of blanket material has been worked out with the provision of 350mm ballast.
3. The recommended minimum thicknesses are valid for tracks with a gauge between 1435 and 1668mm, sleeper length 2.6m and sleeper spacing 0.6m (centerline to centerline).
4. Geo- textile should be provided below blanket layer, if prepared subgrade is of SQ2 soil.
5. To ensure the safety of the track from relative settlement of the ground due to likely low bearing capacity of ground, it is proposed to engage a DDC directly or in scope of EPC contractor for formation design by taking due care of Geology, soil investigations of SilverLine corridor to design and advice the best solution for Ground stabilization to overcome the problem of low bearing capacity with economic criteria.

**6. Recommended Specifications of Blanket Material:-**

In view of the above, specifications of the material for blanket layer over prepared sub-grade should be such that it is well-graded sandy gravel layer of adequate hardness. Particles size gradation curve should be more or less within enveloping curves of blanket material as shown in **Figure below** & Grading Percentages within the range given in **Table 8-17** and should also have following criteria satisfied:

i) Cu> 7 and Cc between 1 and 3
ii) Fines (passing 75 microns): 3% to 10%.
iii) Los Angeles Abrasion value < 35%.

iv) Minimum required Soaked CBR value 25 of the blanket material compacted at 100 % of MDD.

In exceptional cases on technical and economic considerations, LAA value may be relaxed up to 40% with the approval from concerned authorities.

v) Filter criteria should be satisfied with prepared subgrade/ subgrade layer just below blanket layer, as given below:
Criteria-1: D15 (blanket) < 5x D85 (sub-grade)

Criteria-2: D15 (blanket) > 4 to 5 D15 (sub-grade)

Criteria-3: D50 (blanket) < 25 x D50 (sub-grade)

**Table 8-17: Grading percentage of Blanket Material**

| Sl.No | IS Sieve Size | Percent Passing (by weight) |
|---|---|---|
| 1. | 40 mm | 100 |
| 2 | 20 mm | 80- 100 |
| 3 | 10 mm | 63- 85 |
| 4 | 4.75 mm | 42- 68 |
| 5 | 2 mm | 27- 52 |
| 6 | 600 microns | 13- 35 |
| 7 | 425 microns | 10- 32 |
| 8 | 212 microns | 6- 22 |
| 9 | 75 microns | 3- 10 |

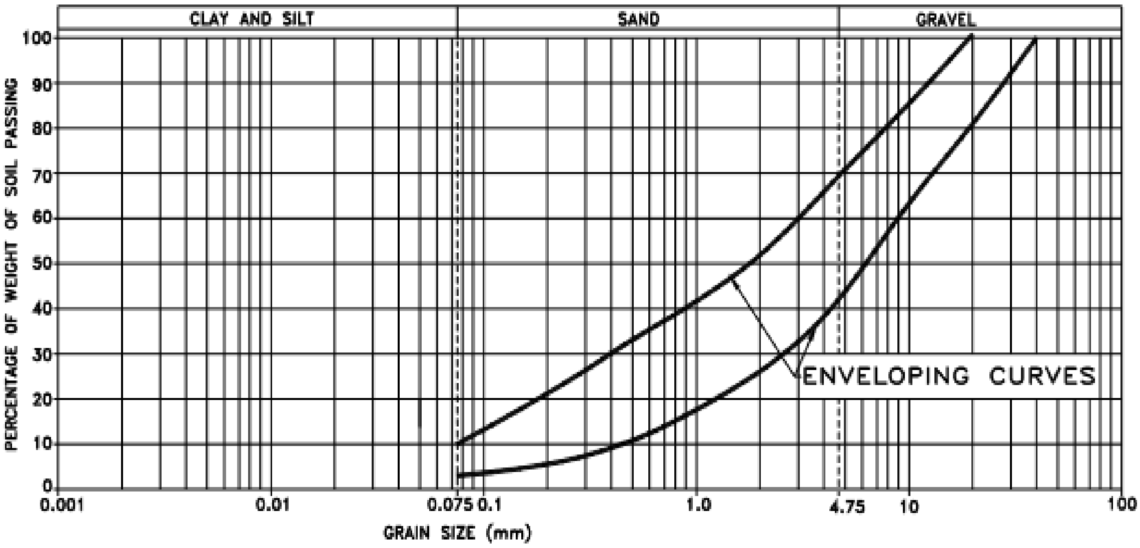



**Figure 8-65: Enveloping Curves for Blanket Material (Ref: Report No. RDSO/2007/GE :0014):**

*Note: For these purposes, the cross slope is considered to be 1 in 30 at top of each layer above natural ground level. It can be 1 in 40 for cement treated embankments/ cuttings and the side slope is considered as 1.5H**:** 1V as per UIC 719 R.*

### 8.9.6 Subgrade classification:-

- **Classification of subgrade:-**

- The bearing capacity requirement of the subgrade **Bearing capacity classes for** depends on;

1. The quality class of the soil which forms an embankment or the natural soil in the case of cutting.
2. The quality and thickness of the prepared subgrade, if this exists.

- Based on the parameters described above a distinction can be made between the three following bearing capacity classes ;

  P1: Poor Subgrade

  P2: Average subgrade

  P3: Good subgrade

- The method of this classification is tabulated below in **Table 8-18;**

**Table 8-18: Determination of the bearing capacity of the subgrade**

| Embankment or Excavation surface | | Class of Bearing Required for the Subgrade | Requirements of prepared subgrade | | |
|---|---|---|---|---|---|
| Quality class of the soil | CBR[a] (min) | | Quality class | CBR[b] (min) | Min. Thickness of subgrade |
| SQ1 | 2[c]- 3 | P1 | SQ1 | 2[c]-3 | - |
| | | P2 | SQ2 | 5 | 0.5 |
| | | P2 | SQ3 | 10-17[c] | 0.5 |
| | | P3 | SQ3 | 10-17[c] | 0.35 |
| SQ2 | 5 | P2 | SQ2 | | - |
| | | P3 | SQ3 | | 0.35 |
| SQ3 | 10-17[c] | P3 | SQ3 | | - |

a. CBR corresponding to the "in situ" conditions of the material (the samples must be saturated during the test)
b. CBR corresponding to a remoulded sample compacted to the design conditions of the material (the samples must be saturated during the test).
c. Proposed values according ERRI Report D117/RP 28 (1983).

- For effective compaction, it is recommended that the maximum particle size is less than half of the thickness of the subgrade layer. The lowest layer of embankments resting on damp ground must be selected from quality class SQ3 (drainage material). The drainage qualities can be improved by using geotextiles.
- General Strengthening of sub-strata soil layers can be carried out using one or more of the following techniques, like:

  - removal and replacement (R&R) of weak soil,
  - stage constructions of the fill, preloading and surcharging,
  - Installation sub drainage system,
  - In-situ pile, Sand Gravel Compaction pile, Stone Columns
  - Vibro-floatation,

- lime pile, Injection/ lime slurry pressure injection/ion exchange,
- Stir & Mixing,
- Sand mat, Geosynthetics etc.

### 8.9.7 Economical design of embankment by use of Geo-Textiles and Geo-Grid:-

#### 8.9.7.1 Case Study:-

The proper designing of embankment is helpful in achieving not only a safe structure but also to achieve an economical cross section. This is proved in the case study done as discussed below;

Mechanized blending and laying of blanketing material along with application of Geo-textiles and Geo-grids in the formation of Agartala- Sabroom of NF railway project caused for development of economical cross section as depicted below in **Figure below** and the corresponding tabulation of saving is also shown in **Table 8-19**;

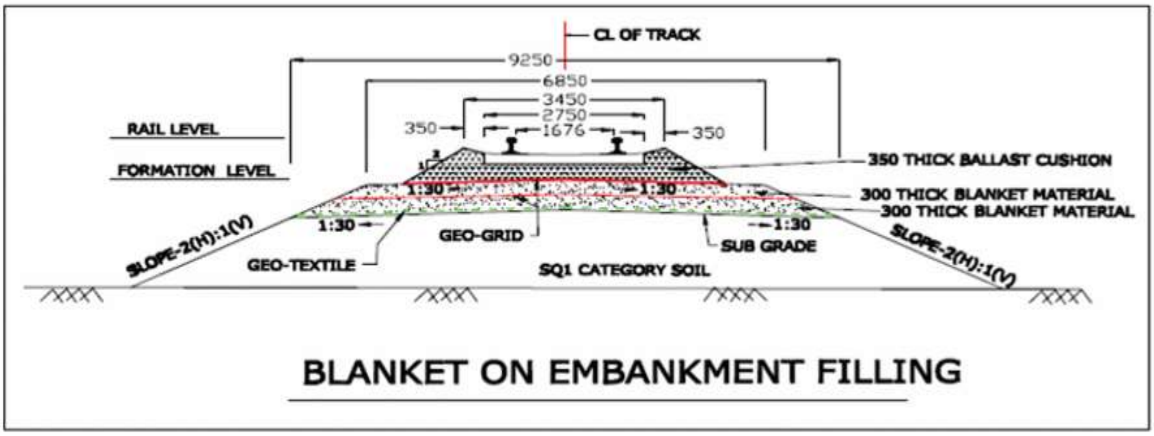



**Figure 8-66: Application of Geo-textiles and Geo-grids in the formation**

**Table 8-19: Economy of Use of Geo- Synthetics (Geo- Textiles and Geo- grids)**

| Blanket | Quantity per meter Track | Cost Rs per Cum/Sqm | Cost per meter of Track | Total cost | Saving |
|---|---|---|---|---|---|
| 1m. Blanket | 8.85 cum | 3650.00 | 32302.00 | 32302.00 | 36% Savings |
| 60cm blanket | 4.83 cum | 3650.00 | 17629.00 | 20619.00 | |

| | | | | | |
|---|---|---|---|---|---|
| with Geo-textile & Geo grids | (8.65+7.50) sqm | (120.83+ 259.87) | 2990.00 | | |

### 8.9.7.2 Geo textiles for Embankment:-

- The geotextile to be used for embankment strengthening is made from polypropylene multifilament yarns, woven together into a stable fabric structure with a superior combination of mechanical and hydraulic properties. Finished product shall have excellent resistance to biological and chemical environments normally found in soils and shall be stable against short-term exposure to ultraviolet radiation. The woven geotextile shall conform to property values listed below:

**Table 8-20: General Specifications of Multifilament Woven Geotextile**

| S.N. | Property | Test Method | | Value (MARV) |
|---|---|---|---|---|
| I | Polymer Composition, Structure and Physical Properties | | | |
| 1 | Polymer | Polypropylene | | |
| 2 | Structure | Woven with multifilament yarn in both warp and weft directions | | |
| 3 | Mass per unit area | ASTM D 5261 | | 240 g/m$^2$ |
| II | Mechanical properties | | | |
| 1 | Tensile strength | Warp | IS 1969 | 55 KN/m |
| | | Weft | | 40 KN/m |
| 2 | Elongation at specified tensile strength | Warp | | 25% |
| | | Weft | | 25% |
| 3 | Trapezoid tearing strength | Warp | ASTM D 4533 | 1100 N |
| | | Weft | | 750 N |

| | | | |
|---|---|---|---|
| 4 | Puncture strength | ASTM D 4833 | 600 N |
| III | Hydraulic Properties | | |
| 1 | Apparent opening size | ASTM D 4751 | 150 microns |
| 2 | Waterflow rate normal to the plane | ASTM D 4491 | 32 $l/m^2/s$ |
| Roll dimensions | | Standard roll length 100m, Standard roll width 5m | |

(Ref: As per Unified Standard Specifications for Works & Materials, Chapter 1, Earth Work)

Typical woven geotextile rolls are shown in **Figure below.**


**Figure 8-67: Views of woven geotextile available in the market**

- **Procedure used to lay geotextile on the prepared surface under blanket layer:-**

The woven geotextile laid directly on the site, having removed major protrusions such as rocks and bush stumps and also having filled local hollows and depressions with the approved fill. The geotextile rolls of specified width laid in the longitudinal direction (parallel to the track) on the prepared subgrade. A 300mm overlap was provided between the joint of two geotextile rolls (transversely and longitudinally). After laying the geotextile, first layer of blanket layer as per drawing was laid and compacted.

**Figure 8-68: Method of laying Geo- textile on the prepared surface**

- **Importance of uses of Geogrids and its function:-**

  Geogrids stabilize the formation by improving lateral confinement and bearing capacity, increasing resilient modulus and decreasing differential settlement.

- **Specifications of biaxial geogrids for trackbed stabilization:-**

Biaxial Geogrids of Punched & oriented type with large aperture with below mentioned specifications are used for trackbed stabilization application. Biaxial Geogrids manufactured from carefully selected polypropylene (PP). Grade of PP used in manufacturing of Geogrids to combine optimum values of strength, stiffness, toughness and durability. Biaxial Geogrids is made by extruding a sheet of PP to very precise tolerances, punching an accurate pattern of holes, then stretching the sheet under controlled temperature, firstly in longitudinal direction, then in transverse direction. Process is to create a geogrid with square or almost square apertures by stretching in two orthogonal directions. The polymers long chain molecules was orientated in the direction of stretching resulting in a dramatic increase in both strength and stiffness. This orientation to pass through both the narrower ribs and the thicker nodes. The resulting product to be monolithic grid with square edged ribs and integral junctions which possesses both geometrical and molecular symmetry; critical for consistency in manufacture and efficient load transfer in service. The geogrid is supplied in standard width of 3.8m and roll length of minimum 40m conforming to Chapter 1 of Unified standard specifications for works & materials of Indian Railways.

Figure 8-69: Laying of biaxial geogrids

- **Recommedation:-**

The design of alignment of SilverLine project is done adopting the aspect of balancing quantities of the cutting and bank in view of the economic considerations. In embankment the good soil is to be used from the cut spoils of the cutting and excavations from other areas. The soil is to be checked for its usable properties as described in the previous paragraphs or to be treated to get the desired standards. DDC to take call on this aspect during execution stage.

In view of the above benefits, the application of Geo-Textiles and Geo-Grids for subgrades is found suitable and kept in the provision of estimates. However, this can be reviewed during execution as per site requirements for its actual applicability.

## 8.10 Drainage:-

Various type of drainage requirements arise in track bed design. Drainage design is an important aspect in designing of the embankment as the formation (embankment or cutting) will be unstable without the same. It is discussed in following paragraphs.

The drainage can be classified into two categories as explained below;

**a) Ground water:-**

If the local hydrological and hydrogeological conditions determined by the position of the watertable, are poor, the bearing capacity of the subgrade and, hence the stability of the track may be affected. This situation can be improved by lowering the ground water table to a minimum distance between 0.8m (only for P3 category of subgrade) to 2.5m below rail top.

**b) Surface water:-**

Any rainwater falling on the surface and likely to penetrate to the blanket layer/subgrade must be quickly eavacuated. This requires minimum cross slope of 1 in 30 including on shoulder towards the longitudinal drainage system in both straight and curved track. However, in canted sections, the subgrade for double-track lines may be designed with a single continous crossfall. Correct dimensioning of the components of the side drainage system to accommodate the run-off produced during the design storm corresponding to the return period of at least ten years, is also a requirement for evacuating the rainfall.

- **Recommendation:-**

Cross sections for formation invariably has to accommodate suitable side drains of adequate capacity, particularly in cutiings, in between tracks, by the side of entry of IR lines and roads. Dimesions are to be designed based on catchment area, rainfall intensity and drain slopes available. Similarly on top of cuttings, catchwater drains are essential to prevent instability of cutting slopes and track flooding.

### 8.10.1 The Provision of Fencing/ Compound Walls:-

The transportation with safety is a prime concern of the SilverLine project. As per prevailing practice in the Railways, there is a need of fencing the railway corridor if the speed is more than 160Kmph, particularly from the point of view of local tresspassing by people and cattle which is prevalent in the country. Cattle run-over is a regular phenomenon in Indian Railways. It is recommended in IRICEN book "Vision of High speed rail corridors in India" at para 7.8 also. The main purpose of providing the fencing along both sides of the SilverLine corridor is to provide safety to the local people residing nearby the tracks, cattle and making the system accident free for running of the trains.

In view of the above reasons, entire length has been proposed with both sides compound walls of adequate heights on at-grade alignment where the alignment is at level or in bank or in cutting. On top of the walls, angle posts can be fixed to mount solar panels as solar panel usage in contemplated in the project.

#### 8.10.1.1 Options of Fencing/ Compound walls along SilverLine corridor:-

Various options as discussed hereunder are available which can be considered for the provision of fencing;

- **Option-1:** Compound wall with precast panels and cast in situ columns over pile foundations:-

A masonry or cement wall (2.4m height) can be built with cast in situ RCC columns at 3m c/c with foundation with two piles (0.2m dia, depth as per design) and precast panels to be fixed with anchor bolts with concertina coil and angle posts to fix the solar panels. This

wall will bear the embossed logo of SilverLine and its other part can be used for advertisements generating extra revenue. This type of arrangement is suitable for advertisement along the corridor. However, its cost is slightly high. **Figure below** shows such an arrangement.


**Figure 8-70: Solar panels on precast RCC Compound walls**

- **Option-2:** RCC Compound wall with barbed wire fencing:-

The cost of this type of wall with fencing is less as compared to option 1 marginally but it is likely to be damaged by the trespassers and more over solar panels fixing will be difficult on the top of it. This is not considered suitable for the SilverLine Corridor. This type of arrangement is not suitable for advertisement. Moreover, its aesthetic is not good as of the option 1. Arrangement is shown in **Figure below**


**Figure 8-71: Showing the tentative cross section of the Fencing**

- **Option-3:** Fencing with barbed wires:-

The cost of this fencing is minimum in all three options, but it is likely to be damaged by the trespassers. It does not have any provision of the advertisements along the corridor and more over solar panels fixing will not be desirable on the top of it. It is also corrosion prone. **Figure below** shows the same.

**Figure 8-72: Showing the tentative cross section of the Fencing**

In view of the terrain and geological conditions of the Kerala and also factors like stability, aesthetic looks, its usability to place solar panels and use of the wall for advertisements so that revenue also can be generated, Option 1 is found most suitable and hence proposed for the SilverLine corridor .

## 8.11 EMBANKMENT CROSS SECTIONS:-

### 8.11.1 General:-

About 62% of route is considered to be constructed with embankment. The maximum height of bank has been proposed as 8m, beyond which viaduct has been proposed especially in urban areas**.** Generally, the land width requirement has been limited by providing RCC retaining walls of designed thicknesses wherever required.

### 8.11.2 Standard Profile:-

If the land value is very low, the conventional type embankment can be adopted. The formation is proposed with a cross slope of 1 in 30 for all the earthen structures. The general cross section of the proposed embankment/ cutting along with the utilities like precast RCC ducts of signal & power and the OHE mast is depicted in the **Figure below** below. This section has been adopted for the track structure for all the structures except above bridges and viaducts where the cross slope is 1 in 40. Two layers of biaxial geogrid at 300mm apart (one below the sub-ballast and one at middle of blanket layer) and one layer of geotextile at bottom of blanket layer, have been proposed to be used. Profile of 12.00 m top width is assured as to accommodate ballast profile along with ducts and masts and also to ensure stability. The space over duct cover provide passage for the maintenance staff and evacuation purposes.

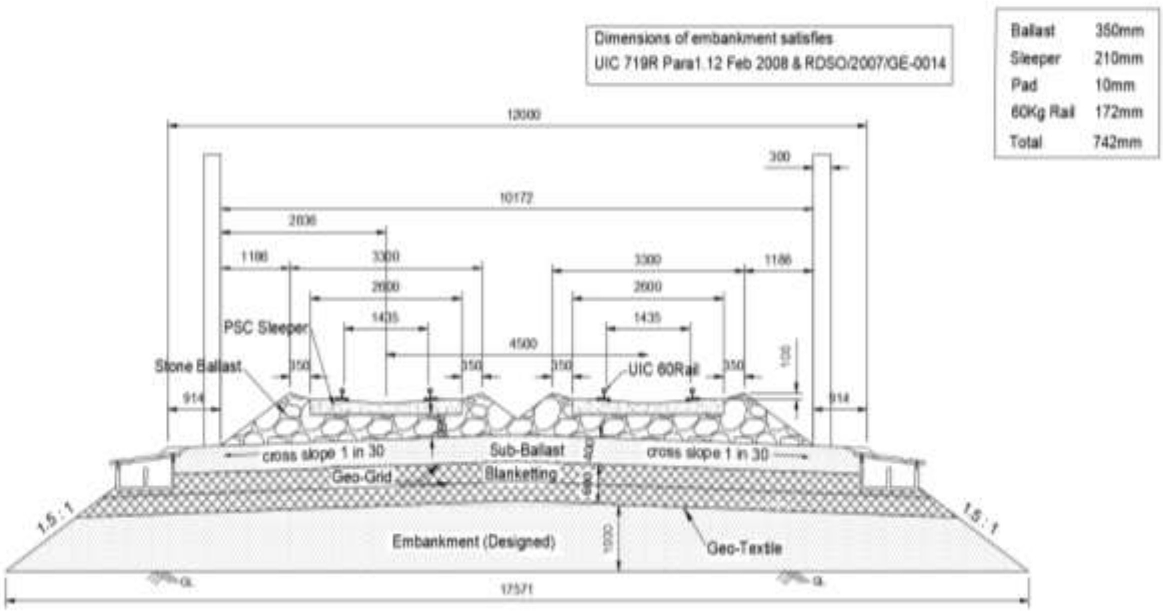



**Figure 8-73: Typical Embankment cross section**

*Note: 3.5m road is proposed for construction period if required on both sides. Service road of 3.5m on one side to be provided as per site conditions.*

- **Provision to accommodate the Power ducts and Signal ducts in embankment**

Precast RCC ducts are proposed on both sides of embankment for accommodating the signal and power cables as shown in **Figure below.** The top width is 1 to 1.2 m which can be used as walkway. The rainwater flow is directed over these ducts by providing a small dip on the formation, which is self-explanatory in the Figure. The OHE mast will be placed immediately after the ballast at certain intervals about 40 to 50m so that the cost of implantations will be minimized.

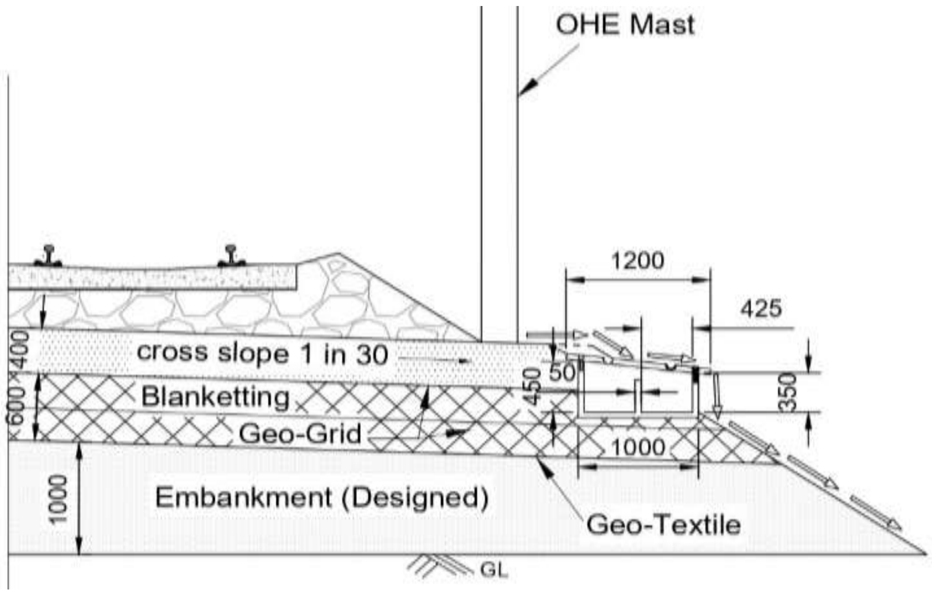



**Figure 8-74: Typical arrangement of signal and power duct on Embankment**

### 8.11.3 Pressure Below Embankments of various heights:-

Neglecting the effect of sleeper spacing for the soil mass of embankment, the Dynamic load, $P_{dl}$ = [1+ 0.0052*v/D]*Psl is considered 3m as width of dispersion below ballast bed.

Where the $P_{sl}$ is Static wheel load and v is speed in Kmph.

**Table No 8-21** below shows the dynamic loads.

**Table 8-21: Calculation of Dynamic load from static load**

| Sl no | Speed in Kmph | Diameter of wheel in m | Axle load in t | Static wheel load in t/m² | Imp. Factor | Dynamic load $P_{dl}$ in t/m² |
|---|---|---|---|---|---|---|
| 1 | 120 | 0.97 | 22.5 | 4.55 | 1.64 | 7.45 |
| 2 | 250 | 0.86 | 16 | 4.27 | 2.5 | 10.67 |

The impact factor is taken as limited to 2.5. The static wheel load is calculated as 22.5/(1.65*3) and 16/(1.25*3) since the corresponding wheel spacing is 1.65 and 1.25 respectively.

The live load and track load are distributed in the proportion 0.5:1 for a width of 3m on top of formation as per BS 5400 part.2. The center to center distance of track is fixed as 4.5m. The height of retaining wall is varying from 0 to 6m corresponding to the embankment height 2 to 8m (from formation to ground level). The highest $P_{dl}$ is 10.67 t/m$^2$ and hence the calculations are done for this combination of speed and axle load.

The pressure bulb value is 0.7P at a vertical distance of B/2, the maximum load intensity below 1.5m from formation is calculated as; 0.7*10.67*3/4.5 = 4.978 t/m$^2$. Adding the loads due to track + ballast+ soil Cushion comes to 3.937 t/m$^2$, the total pressure on soil is calculated as 9 t/m$^2$. At 3m below formation, the pressure factor will be reduced to zero which cannot be considered since the pressure bulb is overlapped, the total pressure on soil is calculated as 11.56 t/m$^2$. Similarly at 8m below the formation, the total pressure is calculated as 20.355 t/m$^2$.

Assuming the impact factor is 0.5*CDA at 1.8m (the double depth of value corresponding to B.G.i.e.0.9m) below sleeper and varying to 0*CDA in next 3m as in IRS substructure code, the reduced $P_{dl}$ has been calculated and the corresponding pressures on subgrade soil has been calculated in **Table 8-22**,

**Table 8-22: Pressure on subsoil when the height of fill below ballast varies**

| Sl no | Height of fill below ballast | Pdl | Reduced Pdl due to depth | Ballast+ fill | Track | Pressure in t/m^2 on subsoil |
|---|---|---|---|---|---|---|
| 1 | 0 | 10.67 | 10.67 | 1.075 | 0.333 | 12.075 |
| 2 | 1.5 | 4.978 | 2.489 | 3.715 | 0.222 | 6.426 |
| 3 | 3 | 4.978 | 1.244 | 6.355 | 0.222 | 7.822 |
| 4 | 4.5 | 4.978 | 1.991 | 8.995 | 0.222 | 11.209 |
| 5 | 6 | 4.978 | 1.991 | 11.635 | 0.222 | 13.849 |
| 6 | 7.5 | 4.978 | 1.991 | 14.275 | 0.222 | 16.489 |
| 7 | 8 | 4.978 | 1.991 | 15.155 | 0.222 | 17.369 |
| | | | | | | 85.238 |
| | | | | | Avg= | 12.18 |
| | | | | | Say | 15 t/m$^2$ |

### 8.11.4 Typical Cross Sections of Embankments:-

Based on the assessment at this stage following tentative cross-sectional profiles have been made for different requirements such as heights for this report for estimate purpose and for execution. Actual execution will be done as per detailed designs by DDC with more site data and required tests on subsoil.
In view of the above and as per requirement of the project at this stage, following typical cross sections of embankment have been evolved. They are discussed further.

**1) Embankment 2 m high on strong ground (SBC>15t/m$^2$):-**

Embankment up to 2 m high have been proposed for the corridor as per following section. This shall be used on good stable ground as per geotechnical investigations. The provision of drainage and road width in one side is also considered. The total land width can be limited to 20m by using RCC toe walls of 1m height on either sides of embankment or as required.

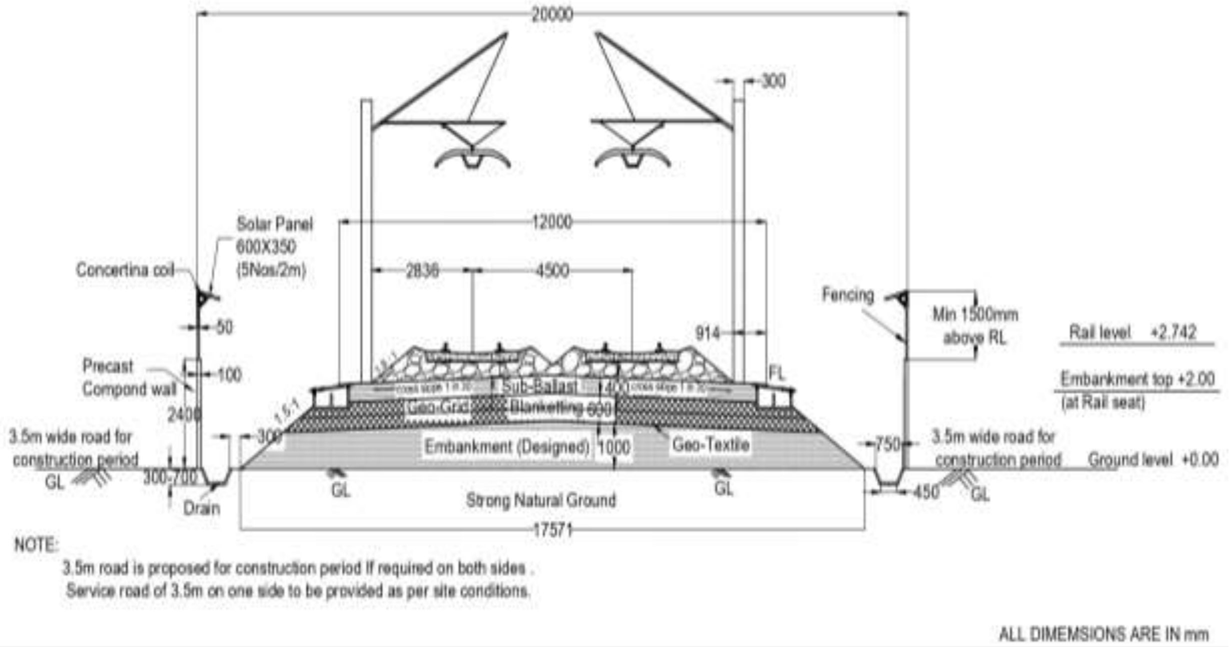



**Figure 8-75: Embankment 2 m high on strong ground**

**2) Embankment 2 m high on weak ground (SBC<15t/m$^2$):-**

The stretches with weak ground are considered to be strengthened by providing stone columns. A typical cross section has been prepared as shown in **Figure below.** Depth up to firm strata has been considered as 8m for the estimate purpose. These are however typical designs. Final decisions to adopt or otherwise have to be made based on actual design following necessay GT investigations and cost aspects involved.

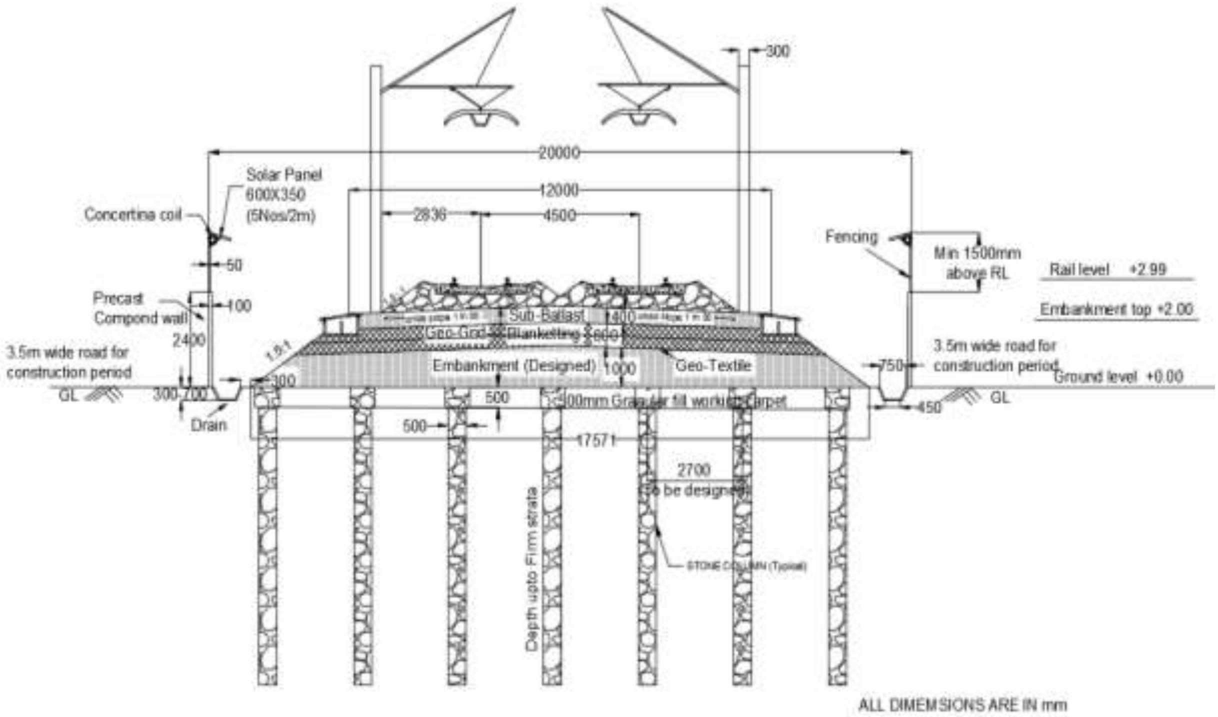



**Figure 8-76: Embankment 2m high on weak ground**

### 3. Embankment 2 m high on very weak ground (SBC< 5t/m$^2$): -

The stretches with very weak ground are considered to be strengthened by providing stone columns wrapped with geogrid and with loading frame (Geotextile layer between bottom of embankment and the granular fill working carpet) for estimate purpose. The geogrid wrap will provide confinement and hence it will help to transfer the load to better strata.

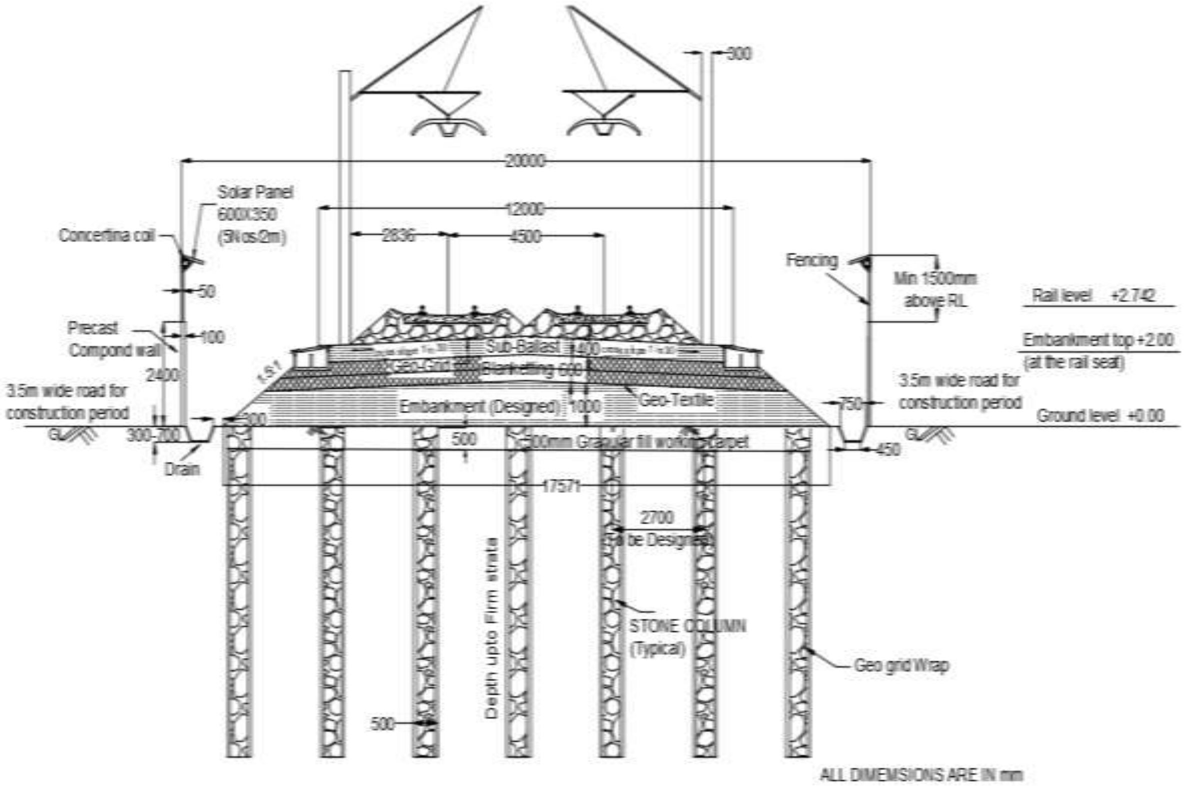



**Figure 8-77: Embankment 2 m high on very weak ground**

## 5. Embankment 0m high on very weak ground (SBC< 5t/m$^2$):-

In the case of very week soils with SBC < 5t/m$^2$ an alternate method of providing a base slab supported by group of under reamed piles with a pile cap, can also be tried out. This method may be cost effective and does not require elaborate machineries and soil strengthening measures. Time required for construction also can be reduced substantially. Construction work shall be done in accordance with IS 2911 part 3 unless otherwise specified herein or in drawings and contract specifications. Load test is also mandatory as per the code. This is to verify the relevance of quote, "*Under reamed piles shall not be used for Railway bridges but used extensively in clayey and black cotton soils for buildings"* vide para 19.7.1 page 714: chapter 19 of unified standard specifications for Works & Materials 2010, Vol II of IR. The uncertainty of the behavior of under reamed piles is due to the reduced uplift capacity, for piles subjected to uplift loads, and due to the absence of reinforcement in the bulb area. In the calculation of ultimate load capacity of a pile, calculating based on soil properties, the bulb diameter has significant role. Hence it is suggested to use ultra-high performances concrete (UHPC) or any fiber reinforced concrete, so that high tensile and compressive strength are assured especially

in the bulb area which is without any reinforcement. By this the reinforcement consumption can also be reduced. The general arrangement of this type of bank is depicted in **Figure below**. This arrangement can also be used for embankment up to 2m high with due compaction of base soil ensured.

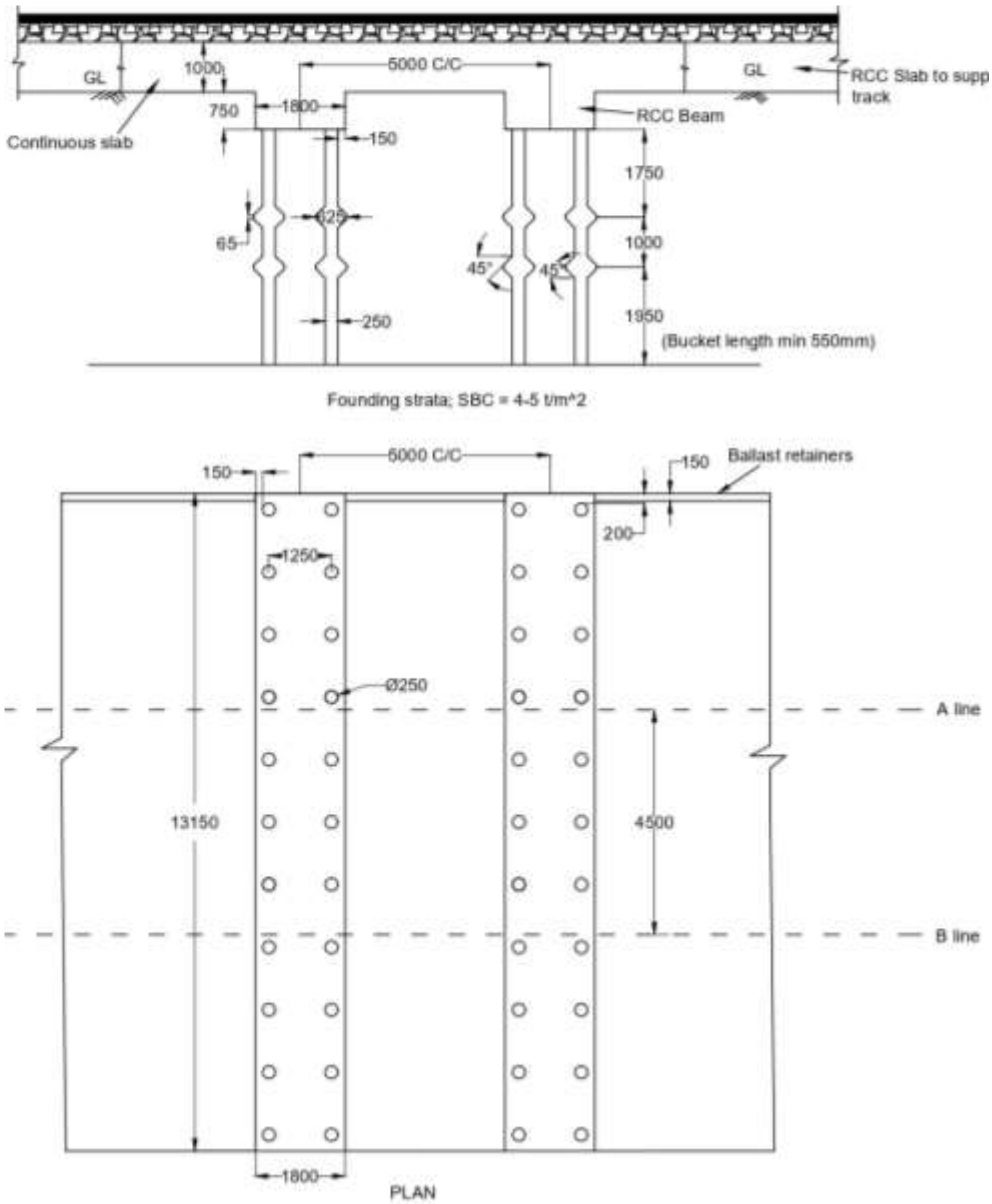



**Figure 8-78: Arrangement of embankment of zero height with under reamed piles**

### 6. Embankment with 2.5 m high clear box at every 500 m along the corridor :-

In view of high speed operations, the corridor has been proposed with compound walls for safety of trains and the public. This however will hinder the local crossings of public, materials and cattle. Therefore, provision of 2.5 m clear height box subways, at every 500 meters has been considered a necessity in the project and the same has been kept in the

cost of the project to facilitate local people. Its height can be reviewed during execution for actual need and height as per site requirements. Box has been provided for full width of embankment to avoid any entry to the track by public.

Where the semi high speed corridor is laid adjacent to the existing Indian Railway tracks, provision of these crossing boxes shall be done in consultation with the Indian Railways as it could result in unauthorized crossing over the existing rail tracks.

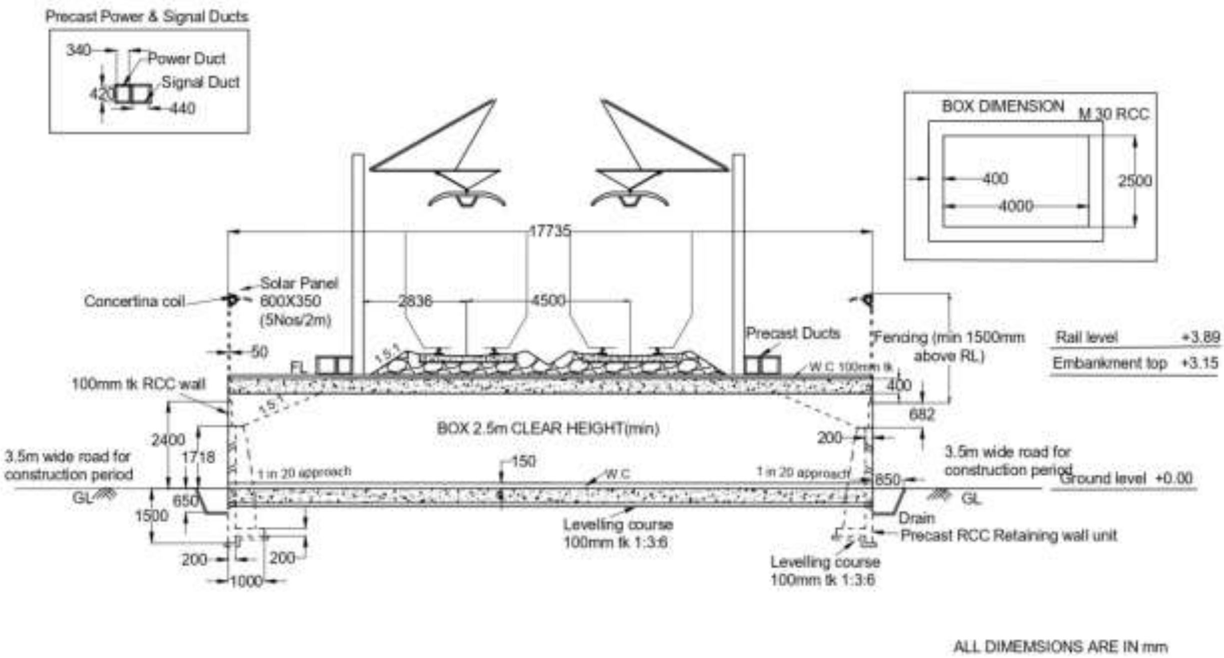



**Figure 8-79: Embankment with 2.5 m clear box on strong ground**

7. **Embankment with 2.5m clear box, on weak/ average ground (SBC<15 t/m$^2$)- with stone columns:-**

It is to be taken care to provide extra stone columns below the retaining walls also. Generally, the pressure on soil below the box is less than 15 t/m$^2$. Hence the requirement of stone columns below the box base slab other than embankment portion will be reviewed by DDC at the execution stage when the more soil data will be available at close interval.

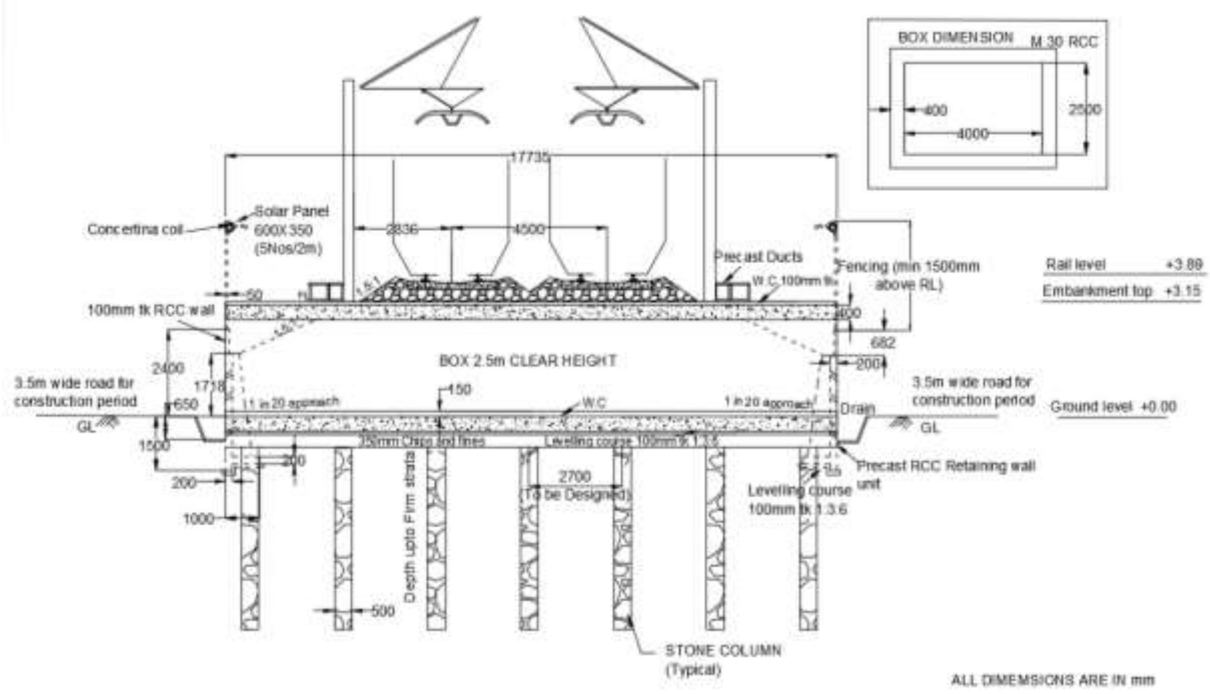



**Figure 8-80: Embankment with 2.5 m clear box on weak ground**

## 8. Embankment with 2.5 clear box, on very weak ground (SBC<5 t/m$^2$): with stone columns wrapped with Geo grid:-

As shown in the **Figure below,** stone columns to be provided with wrapped geogrid, below the retaining walls. The soil stabilization is required below the box base slab also as per site requirements.

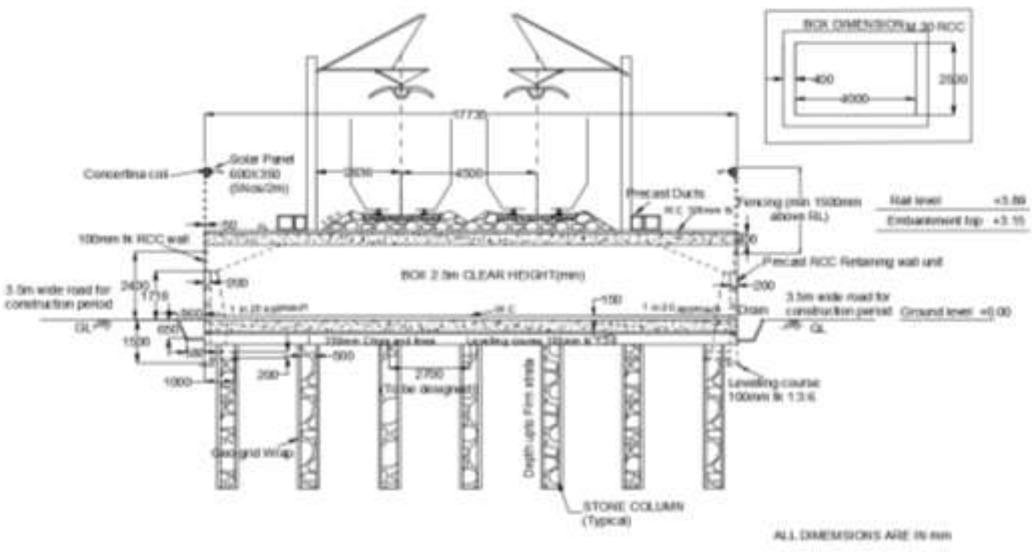



**Figure 8-81: Embankment with 2.5 m clear box, on very weak ground**

## 9. Embankment with 3.6 m clear box, on strong ground:-

For minor road crossings, 3.6m clear height RCC box is considered for bus/ lorry crossing along the corridor for estimate purpose. This can be reviewed during execution period to increase the height as per site requirements selectively.

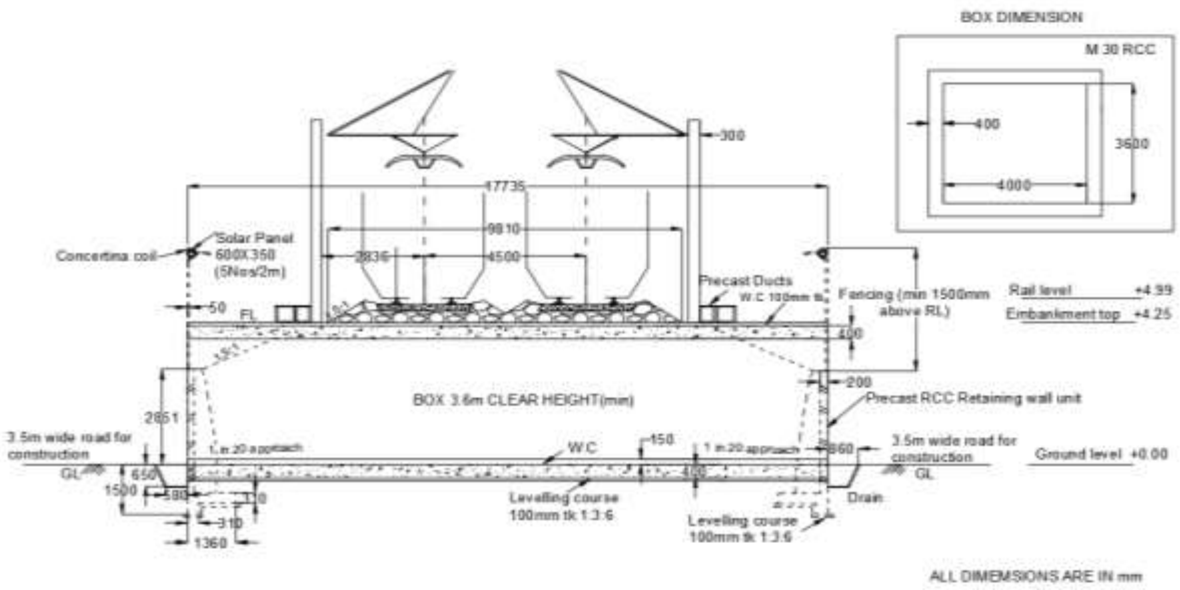



**Figure 8-82: Embankment with 3.6m clear box on strong ground**

## 10. Embankment with 3.6 clear box, on weak ground, on stone column (SBC< 15 t/m$^2$):-

The provision of stone columns below the base slab of box have been considered in this case however stone columns may not be required at all the locations. It can be reviewed at the time of execution since the pressure on soil below box is likely to be less than 15 t/m$^2$.

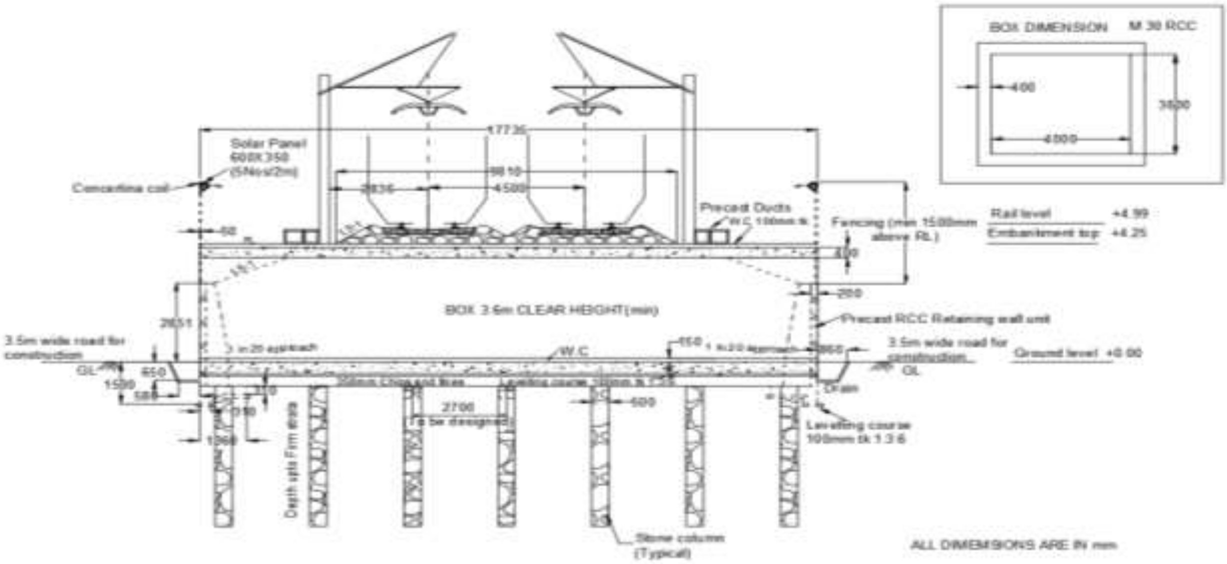



Figure 8-83: Embankment with 3.6 clear box on weak

## 11. Embankment with 3.6 clear box, on very weak ground, on stone column wrapped with geogrid (SBC< 5 t/m$^2$):

It is desirable to provide soil stabilization/ stone columns wrapped with geogrids below the base slab of box as depicted in the **Figure below;**

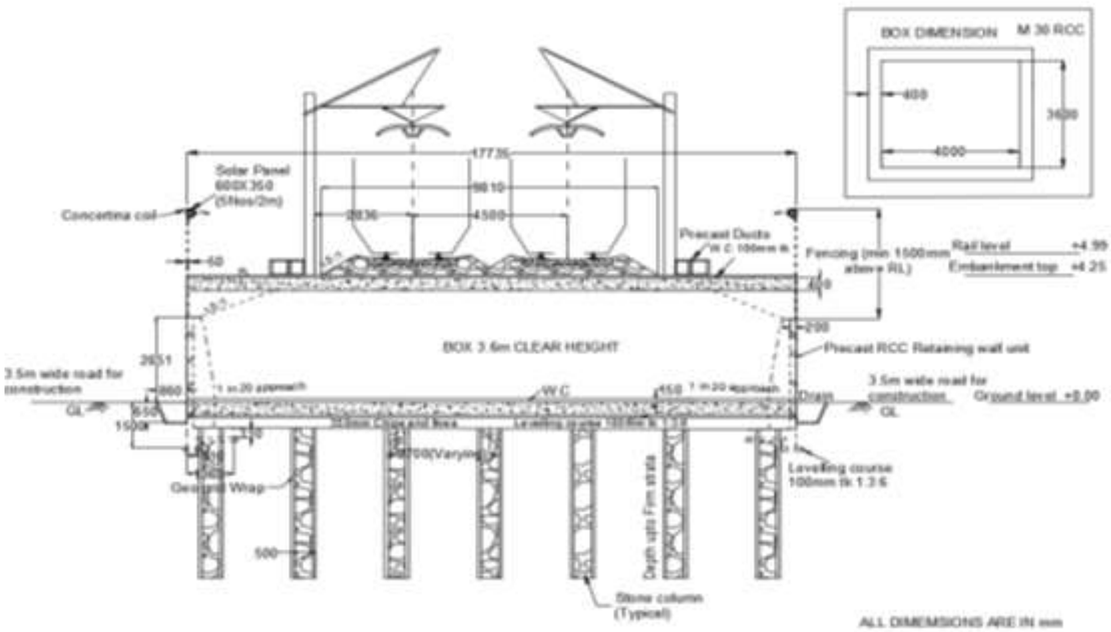



Figure 8-84: Embankment with 3.6 m clear box on very weak ground

**12. Embankment > 2m height and up to 8m height- (typical cross section where land cost is high):-**

a. The section shown in **Figure below** has been proposed generally where the land cost is high. The dimensions of stem and heel slab of retaining wall will vary according to the height of embankment and to be provided as per the detailed design.

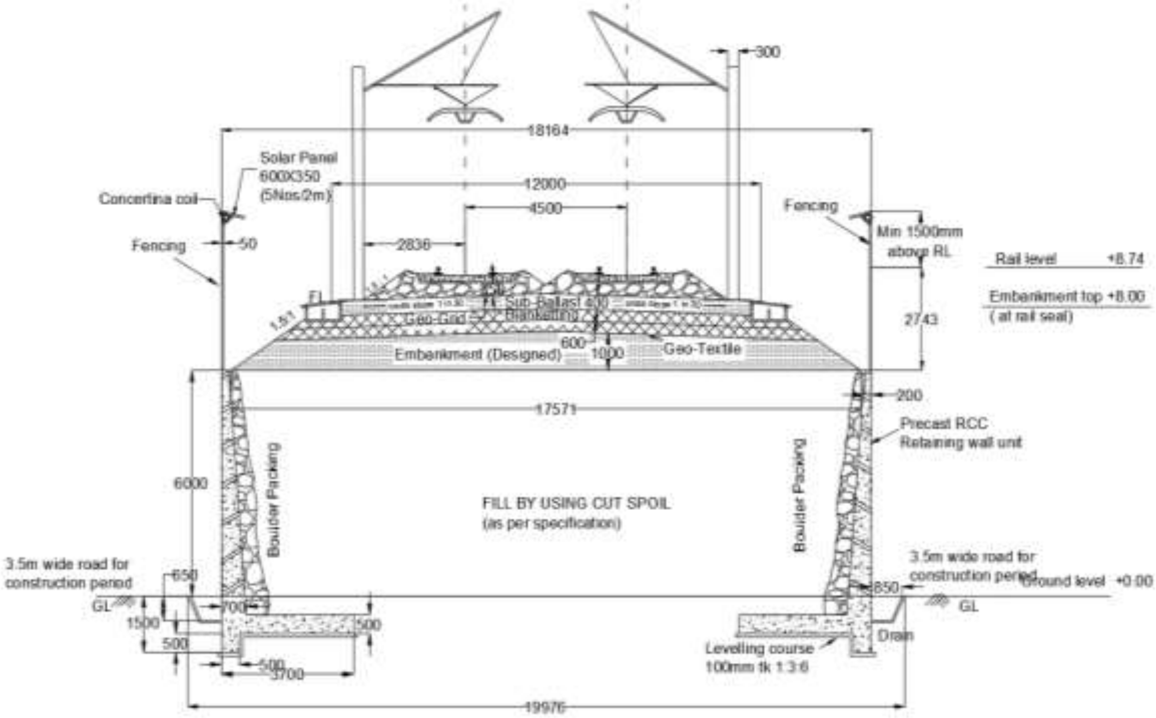



**Figure 8-85: Embankment 2m-8m high where land cost high**

**b. Embankment with Geosynthetic-reinforced Soil Retaining Walls (GRS RWs) :-**

The GRS structures were extensively used for the construction of high-speed train lines which is among the most critical and important infrastructures in japan. Among the various GRS structures used, GRS RWs have been constructed for a total length of about 150 kms as of June 2013 for railways, including high-speed train lines there. After a full height wrapped-around GRS wall has been constructed and the major residual deformation of the backfill and supporting ground has taken place, a full-height rigid (FHR) facing is constructed by casting-in-place concrete on wrapped-around wall face in such that it is firmly connected to the reinforcement layers. A number of conventional-type RWs and embankments collapsed during

earthquakes, heavy rains, floods, and storm wave actions happened in 1995 and in 2011 in East Japan. Many of them were constructed to this type GRS RWs and Geosynthetic-reinforced embankments. ( *Reference article: "Geosynthetic-Reinforced Soil structures for Railways in Japan" in journal "Transportation Infrastructure Geotechnology volume 1-page 3-53 (2014)*). Based on the above reference, a typical cross section evolved is shown in figure 8.87 which is particularly useful along paddyfields.

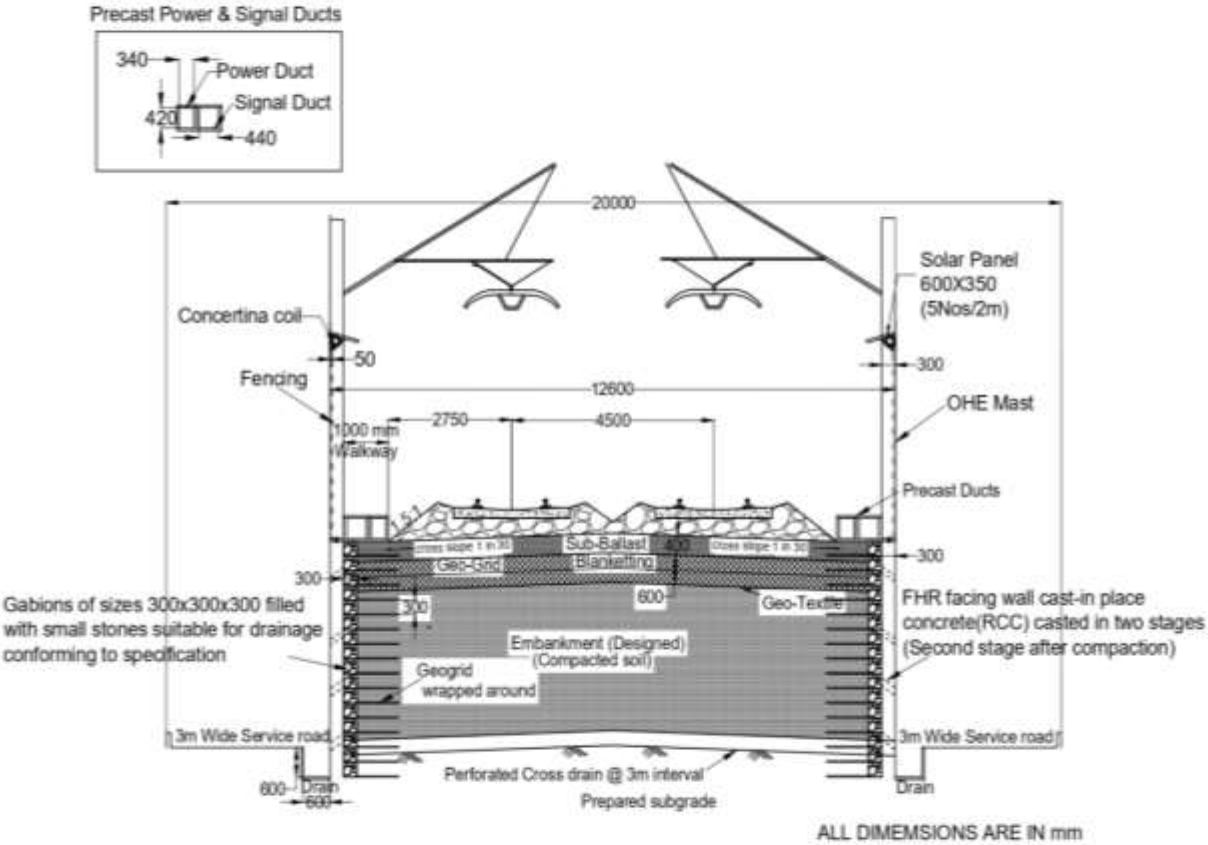
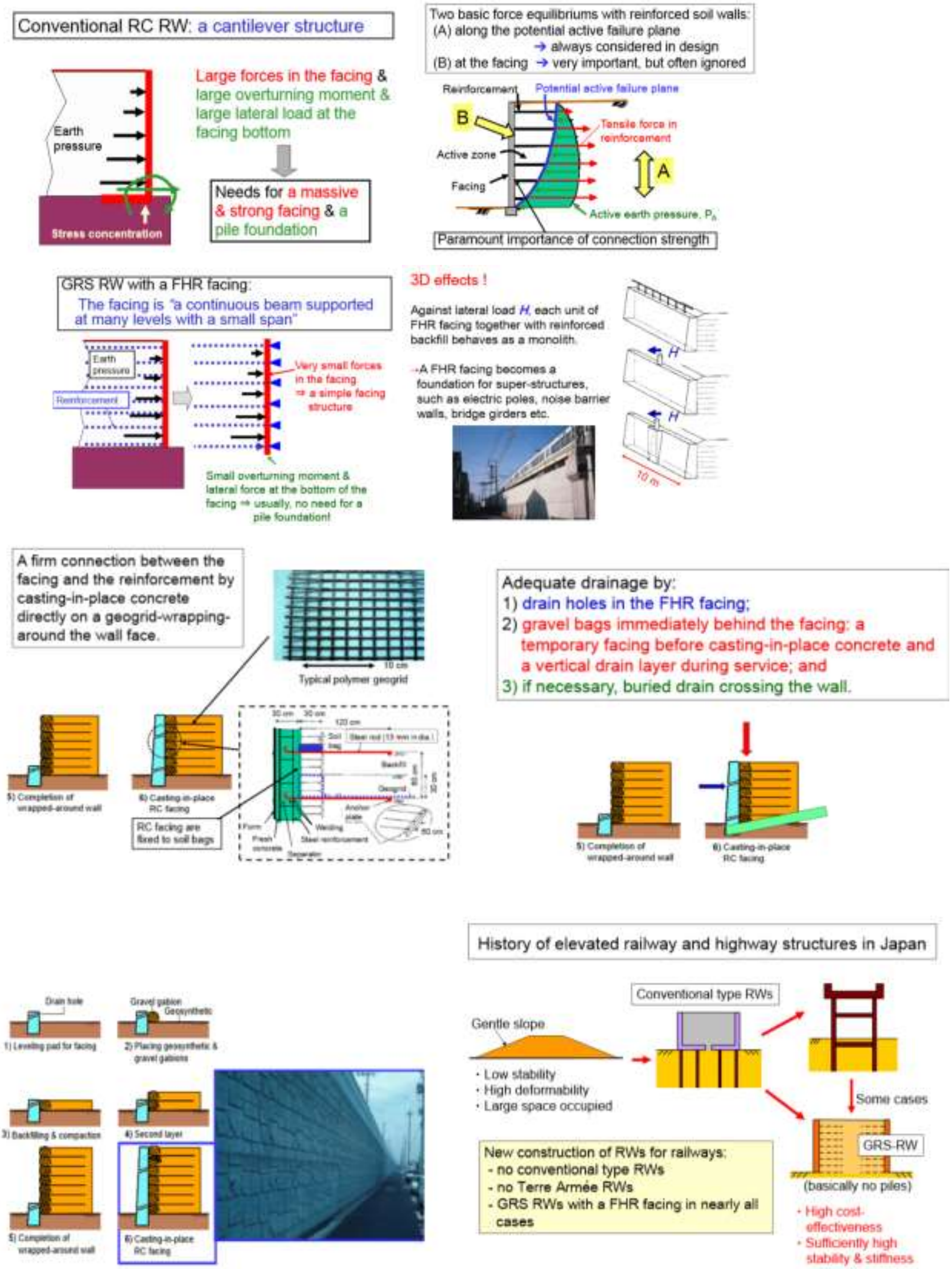



**Figure 8-86: Typical cross section of Geosynthetic-Reinforced Embankment**

- **Evolution theories are shown below;**


Conventional RC RW: a cantilever structure
Earth pressure
Stress concentration
Large forces in the facing & large overturning moment & large lateral load at the facing bottom
Needs for a massive & strong facing & a pile foundation
Two basic force equilibriums with reinforced soil walls:
(A) along the potential active failure plane
→ always considered in design
(B) at the facing → very important, but often ignored
Reinforcement
Potential active failure plane
B
Tensile force in reinforcement
Active zone
A
Facing
Active earth pressure, $P_A$
Paramount importance of connection strength
GRS RW with a FHR facing:
The facing is "a continuous beam supported at many levels with a small span"
Earth pressure
Reinforcement
Very small forces in the facing ⇒ a simple facing structure
Small overturning moment & lateral force at the bottom of the facing ⇒ usually, no need for a pile foundation!
3D effects !
Against lateral load H, each unit of FHR facing together with reinforced backfill behaves as a monolith.
→A FHR facing becomes a foundation for super-structures, such as electric poles, noise barrier walls, bridge girders etc.
H
H
10 m
A firm connection between the facing and the reinforcement by casting-in-place concrete directly on a geogrid-wrapping-around the wall face.
10 cm
Typical polymer geogrid
5) Completion of wrapped-around wall
6) Casting-in-place RC facing
RC facing are fixed to soil bags
Adequate drainage by:
1) drain holes in the FHR facing;
2) gravel bags immediately behind the facing: a temporary facing before casting-in-place concrete and a vertical drain layer during service; and
3) if necessary, buried drain crossing the wall.
5) Completion of wrapped-around wall
6) Casting-in-place RC facing
History of elevated railway and highway structures in Japan
Drain hole
Gravel gabion
Geosynthetic
1) Leveling pad for facing
2) Placing geosynthetic & gravel gabions
3) Backfilling & compaction
4) Second layer
5) Completion of wrapped-around wall
6) Casting-in-place RC facing
Conventional type RWs
Gentle slope
· Low stability
· High deformability
· Large space occupied
Some cases
GRS-RW
(basically no piles)
New construction of RWs for railways:
- no conventional type RWs
- no Terre Armée RWs
- GRS RWs with a FHR facing in nearly all cases
· High cost-effectiveness
· Sufficiently high stability & stiffness

## 13 Embankment > 2m height and up to 8m height- (typical cross section where land is not high):-

The **Figure below** shows the typical cross section of embankment up to the maximum height of 8m to adopt where the land is cheap and available to acquire easily. After 6m height of embankment, from formation level towards ground, 3m wide beam is required.

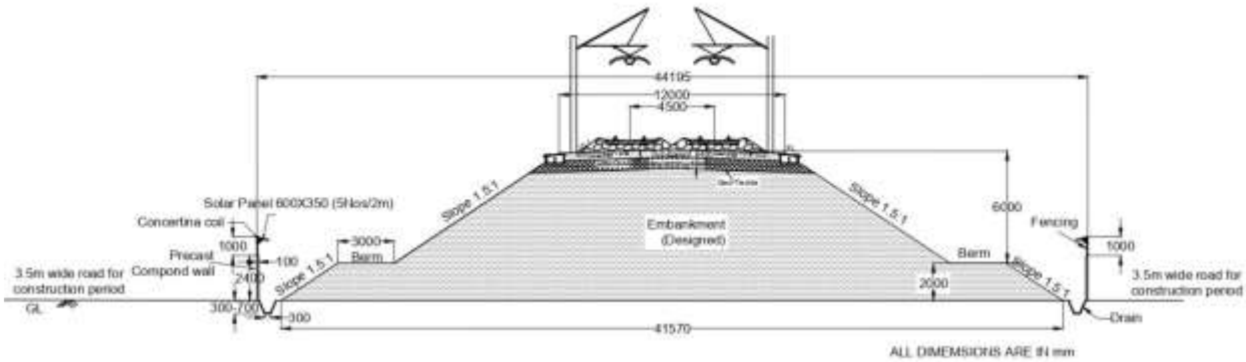



**Figure 8-87: Typical cross section where the land cost is not high**

### i. Embankment where the risk of soil piping problem is likely:-

Particularly in the northern part of the corridor, piping may occur when water erodes beneath the surface of the ground creating an underground tunnel known as soil pipe. This usually begins as small pores underground and are enlarged with increase erosion. In areas where there are cracks in the soil or areas of less resistance, water will start to move through creating a void. Eventually after constant erosion the surface layer of the ground will not have any support beneath and thus collapse creating a depression. These voids provide an opening for moving water and create ideal situations for soil pipe formation. As more water seeps into the bank, the soil becomes heavier and more likely to break apart making it prone to erosion and failure. Since it occurs beneath the soil it makes it difficult to identify the soil pipe up until the ground has collapsed. Small openings known as flute holes connect the soil pipe to the surface.

Soil piping is a natural process, but often human induced activities may result into change in surface and underground water flow and result in increased subsurface erosion and making soil pipe a potential risk. Soil pipe collapse may become a threat to the stability of a railway bank. When considering flood defense, there are always new engineering solutions that can be adopted while constructing embankments next to a river to reduce the effect of soil piping.

One of the measures proposed here is driving of sheet piles of size 1000x 300 mm at 75mm gap for adjusting tilt of 1 in 150, near the side of embankment where the hydraulic gradient is h. The depth of sheet pile below existing ground level is taken as D. Heave piping may occur within D/2 on the downstream of sheet pile, as per Terzaghi. Let the average excess hydrostatic pressure at the base of the soil prism of size D x D/2 beyond sheet pile is 0.35h (average of the equipotential line,a general value adopted in the book “Soil mechanics and Foundation Engineering” by K. R. Arora).

Now, Upward seepage force, U= $r_w$. (0.35 h)(D/2 x 1) per unit length.

Downward force due to submerged weight W’ = r’ x ( D/2 x D)

Keeping the factor of safety with respect to heave piping, F= 2;

F= $\underline{W'}$ = r’D/ ($r_{w.}$ $h_a$) = (1.76-1) x D/(1x 0.35 h) = 2 x (D/h)U

Hence, when D=h, there will be a factor of safety of 2. A maximum hydraulic gradient of 4m has been considered in the **Figure below**;

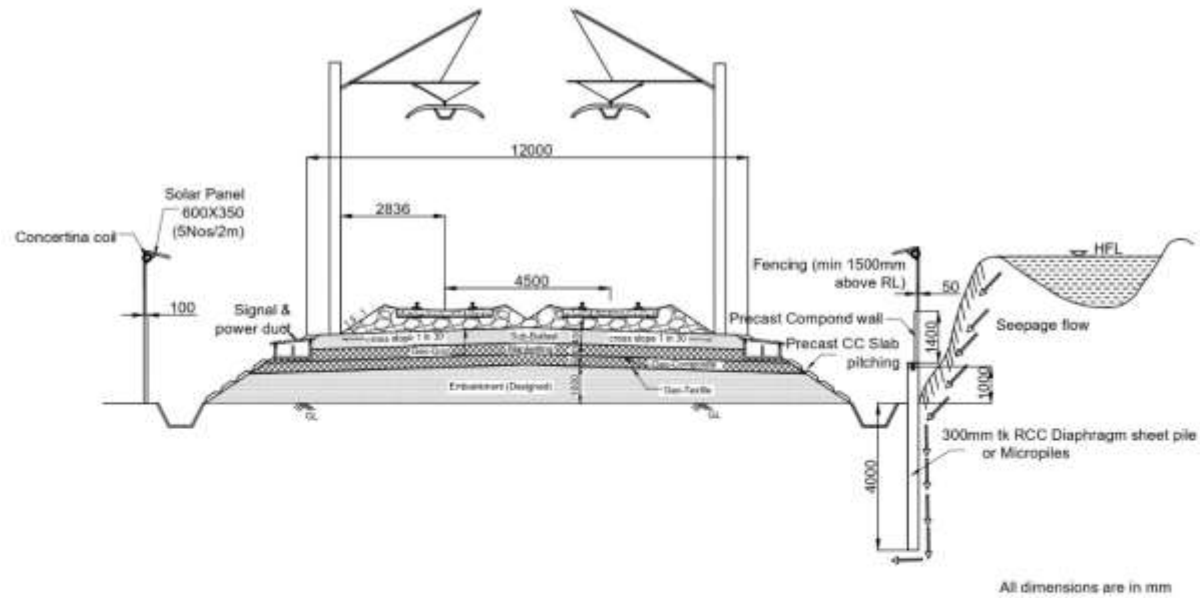



**Figure 8-88: Measures with RCC sheet piles against soil piping**

## ii. Embankment without blanketing using dry lean mix concrete bed:-

Wherever the subsoil is very weak, a dry lean mix concrete bed (in proportion Cement**:** Aggregate as 1:30) or hydraulically bound bed for a thickness of 300 mm can be provided above the subsoil as part of embankment or as per design on the basis of soil properties. This will prevent the penetration of ballast into the subsoil, in case of no blanketing, and hence avoid the mud pumping. This will be done as per site requirements on recommendation of DDC.

## 8.12 CUTTING SECTIONS:

### 8.12.1 General

The best maintained cut sections are the best constructed ones and vice-versa. This calls for providing optimum technical inputs at the construction stage itself. Good engineering practices demand that adequate attention is paid at every stage- survey, alignment selection, in understanding geology of terrain, analysis of data and design, apart from adhering to standards of construction and maintenance.

Railway formations in cuttings have unique problems as they pass through hilly terrain having different characteristics regarding type and deposition of the soil. Moreover, failures in cuttings take place normally without advance warning causing risk to safe running of traffic.

Design of cuttings for railway track is the most important control point for a safe and reliable train operation. It will require proper design of following components;

a) Slopes for stability
b) Formation with or without blanket and geo-synthetics for base preparation.
c) Erosion and slope protection works.
d) Side drains
e) Catchwater drains

Cutting of earth is done from top to bottom usually, however design proceeds from bottom to top. A cut section has following components;

i) Bottom width which includes the formation, side drains, catch ditches, trolley refuges, retaining walls etc.
ii) Side slopes which will include stable slope design, benching or berms, contour drains, pitching and erosion protection works etc.
iii) Top which will incorporate catch water drains and slope stabilization for the terrain.

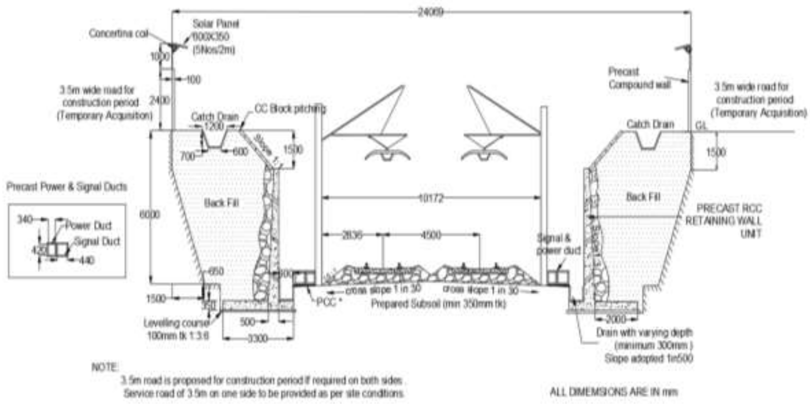
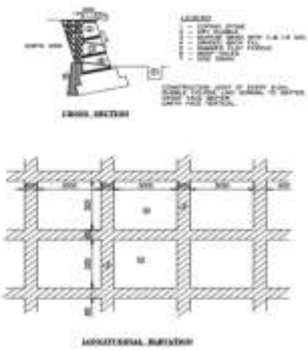
### 8.12.2 Slopes and slope protection Measures:-

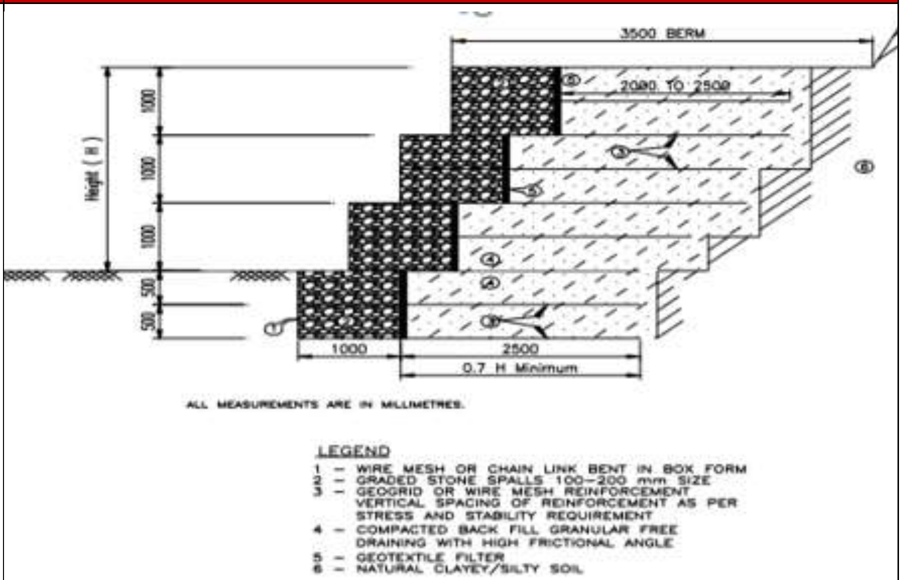
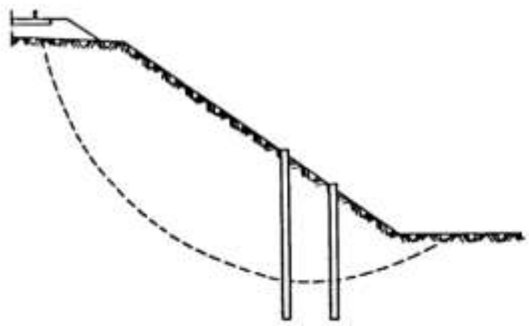
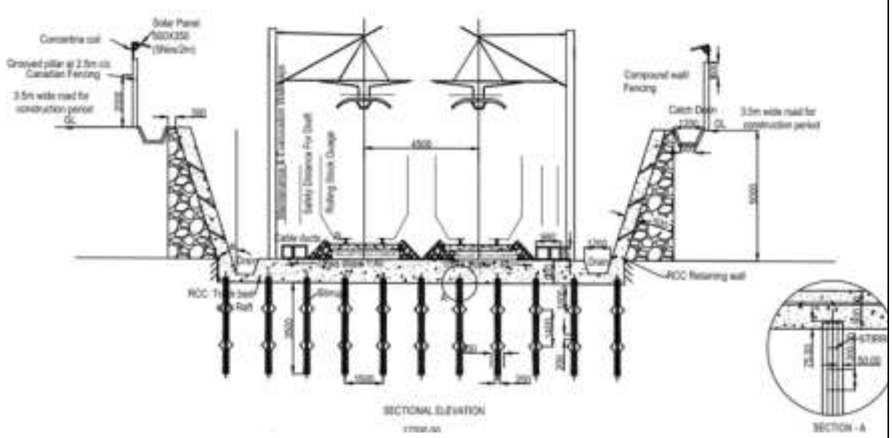
Cuttings are provided with 1:1 in ordinary soils. With good Drainage measures this additional protections are not necessary. However, in sandy or weathered soil special protectios are necessary. In loose sandy soils flatter side slopes will be necessary which should be based on soil properties, as per design by DDC.

**8.12.2.1** The vegetation coverage (grass turfing) and pitching are almost certainly the best forms of slope protection, particularly against erosion of soil slopes.

**8.12.2.2** Other protective works, suitable to keep steep side slopes in cutting and thereby to accommodate the track in the limited land width, generally adopted are as follows:

**Table 8-23: Other Slope Protection Measures**

| S.No | Slope protection works | Figure illustrating the related work |
|---|---|---|
| 1 | Mortared masonry or concrete retaining wall. |  |
| 2 | Banded masonry dry rubble retaining wall. |   |

| S.No | Slope protection works | Figure illustrating the related work |
|---|---|---|
| 3 | Gabion wall with or without earth reinforcement |  |
| 4 | Slope protection with pre-stressed ground anchors or soil nailing. | <br>· Example of stabilisation of the base of slope using conventional piles |
| 5 | Lining of cuttings |  |

**8.12.2.3** All the above protective works and their suitability considered for the project are discussed in detail hereunder;

**1) Concrete Retaining walls/RCC walls:-**

RCC walls has to be provided, as a toe support to the soil slopes. In the design of these retaining walls, the thrust on back of the wall due to earth pressure is taken into consideration and the wall is constructed with required thickness and weight to resist the movement of soil mass from behind. Backfilling of the walls is done with granular materials or small stones to decrease back pressure on walls and help drainage through weep holes provided in the walls.

The cutting of earth is done from top to bottom. If the land usage is to be limited, vertical RCC retaining walls can be adopted with increased stem thickness at bottom. The RCC catchwater drain at top can be provided above the backfill. It is advisable to provide berms in soil slopes at every 6 to 7 m height to break monotony of slopes. Width of first berm from formation may be kept around 5 m and that of subsequent berms around 4 m.

Maximum depth of 9m has been considered for open cut structure in this project. Beyond which Cut and cover method is suggested.

**2) Banded Dry masonry wall:-**

Dry rubble wall with horizontal and vertical mortared bands is commonly adopted in hill road construction in various States. This arrangement has significant advantage of permitting drainage through the wall cross section and thereby release of pore pressure build up which is the basic requirement of cutting. Typical arrangement is shown in **Figure below;**

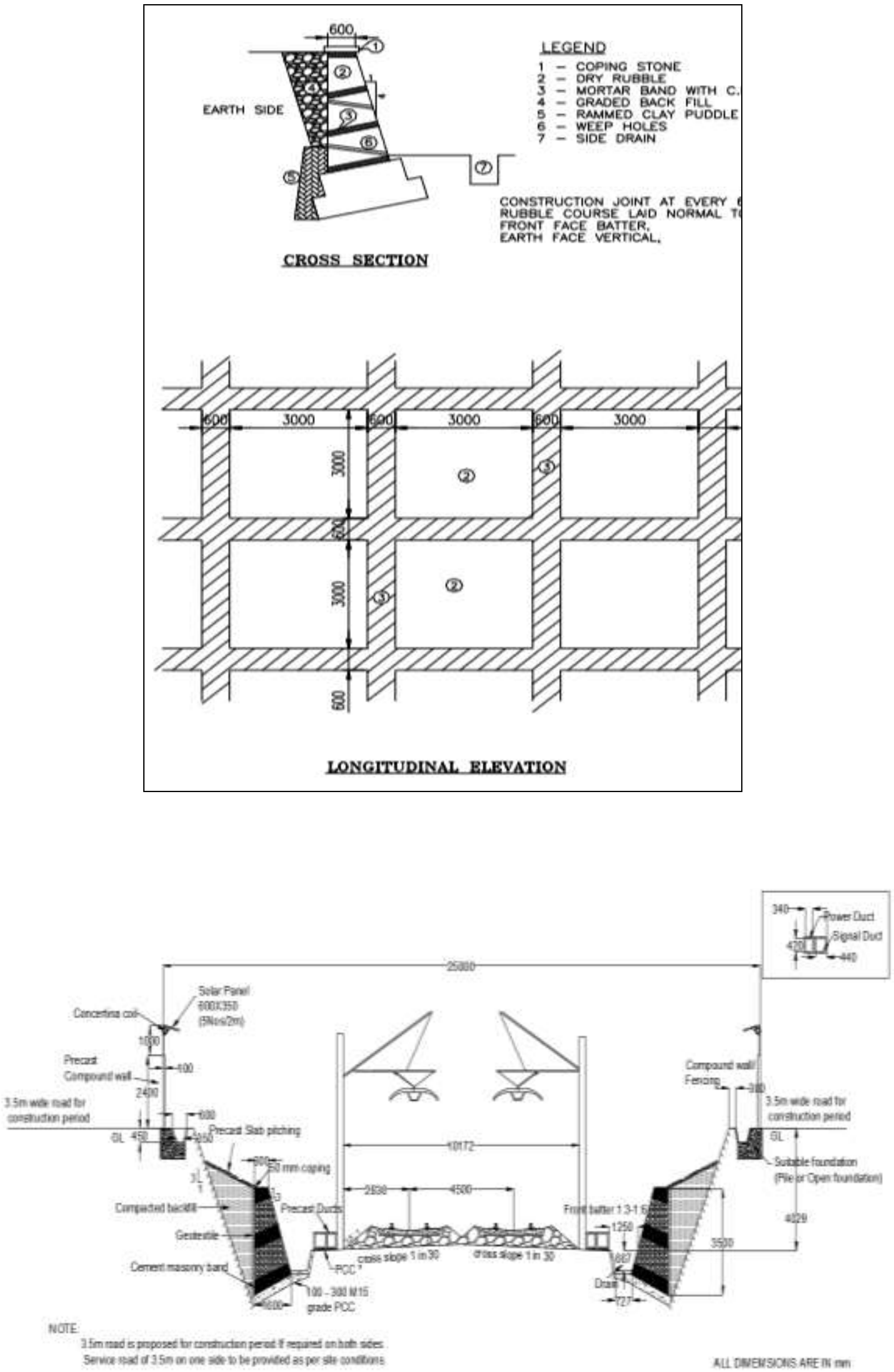



**Figure 8-89: Banded Dry Masonry wall**

### 3) Gabion walls:-

Gabion retaining walls are mass gravity structures that are often used because of their economic, functional, and aesthetic characteristics. These characteristics combined with other advantages, such as their flexibility and permeability; make them a good alternative to other types of retaining structures. The design principles are simple and rudimentary.

Gabions provide a versatile method of constructing retaining walls speedily and economically. Gabion is basically a rectangular box strongly made up of steel wire-mesh which can be assembled at site and filled with hard local boulders/stones. The gabion boxes come in several sizes of 2 m to 4 m length, 0.3 m to 1 m width and 1 m in height. The steel wire-mesh of gabion is square, or hexagonal, doubly twisted and galvanized/PVC coated to prevent its corrosion. The assembled gabions can be tied together, braced and finally placed firmly at toe of cutting slope. The process is carried out in-situ i.e. at the location where the gabions are to be installed. However, this type of retaining walls seem to be more suitable where abundant quantity of local stones is available.

Gabions are also assembled from perforated geogrids. Geogrids, which are made of polypropylene, have high resistance to impact and weathering besides possessing good strength and elongation characteristics.

A row of gabion walls may be placed at the toe of the slide so that these serve to improve the stability of the slopes by their dead weight. It is a common practice to use gabion walls to serve as breast walls as well as in the middle of running slopes where they serve as check-walls. In such applications, gabion walls help to retard the flow of water and reduce the surface erosion of the slope, to a certain extent. Figure given below illustrates the gabion wall;

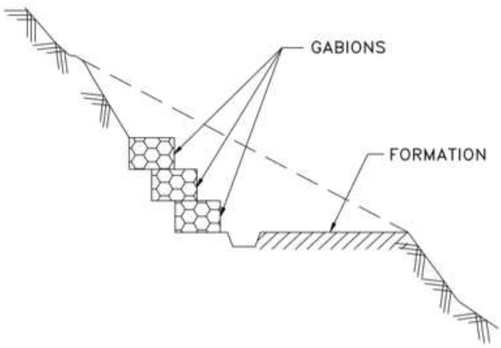



**Figure 8-90: Gabion Wall**

Geogrid reinforced gabion walls have the advantage of reinforcing the fill soil with geogrid and improving drainage through filling of graded stones inside gabions. By properly choosing the backfill with highly frictional material, shear resistance to sliding can be

greatly enhanced and earth pressure on gabion can be significantly reduced. Typical arrangement is shown in **Figure below**. This proposition calls for wider excavation width to accommodate reinforcement length and gabion width than conventional excavation width for rigid retaining walls. Cost of land and safe excavation aspects are to be examined before finally adopting.

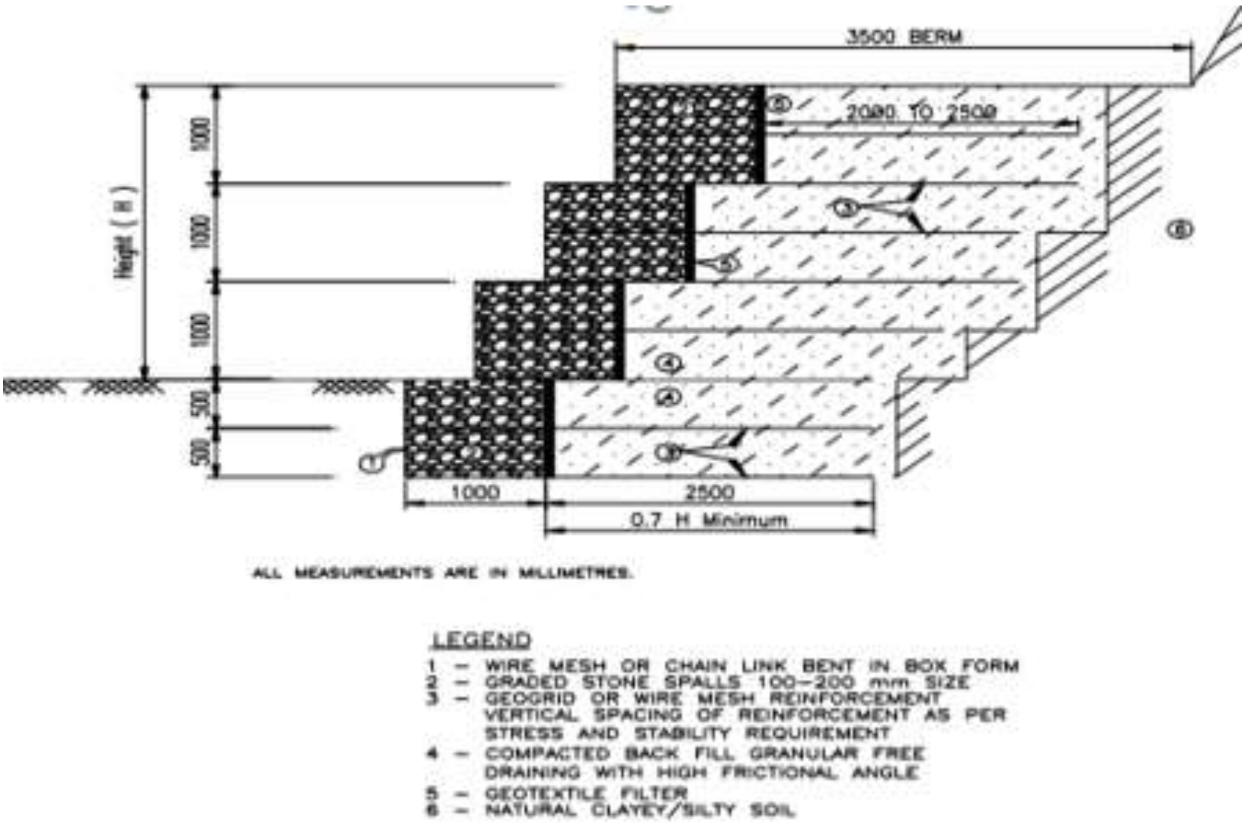



**Figure 8-91: Gabion Wall with Geo grid Reinforcement**

#### 4) Soil Nailing:-

Wherever slope flattening is not possible, properly designed soil nails have been provided over the soil slope to increase overall stability of soil mass. Soil nailing is a soil support system in which in situ soil strata in the cutting slope is reinforced with the help of nails. The objective of the soil nailing is to create the reinforced soil mass that has sufficient internal stability so that it will provide additional safety factor against movement due to sliding.

Soil nails are not tensioned. They are passive soil reinforcements. These nails usually consists of solid tor/steel bars of dia generally 20 mm to 50 mm, and length depends upon soil strength and its condition. The nails are normally placed at an inclination of 0 degree to 30 degree with the soil slope. This is depicted in **Figure below**.

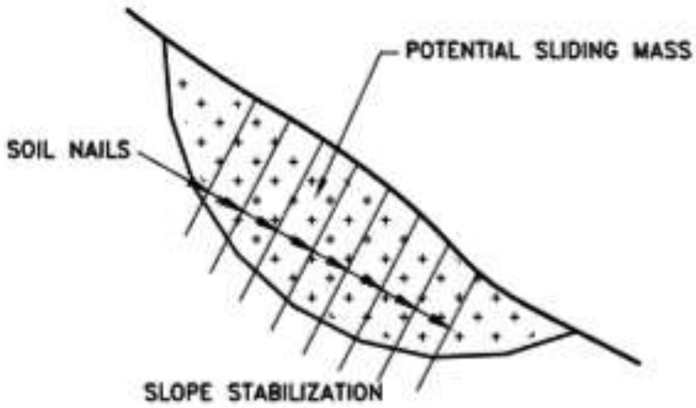



**Figure 8-92: Soil nailing of a failure prone slope**

Once installed across a potential failure plane, tension developed in the nails provides resisting forces which stabilize the soil mass. The tension in the nail is developed by friction and adhesion at soil/nail interface. In addition to tension, resistance to bending also contributes to the reinforcing capacity through the nail acting in shear. Further, the face is protected by a chain link mesh.

For installing soil nails, the holes of appropriate diameter are drilled. Casing pipes are used, if necessary. Drilling rig is used to excavate soil and subsequently nails are pushed into the holes. The drilling casing is removed from around the nail and the annular space between the nail and borehole is grouted with cement or suitable material. For permanent applications, nails are epoxy coated for preventing corrosion. These types of nails are known as ‘Grouted Soil Nails.

**5) Lining of cuttings:-**

Lining on slopes can be done for shallow and short cuttings only. As wherever there is heavy pore pressure inside the soil, provision of lining is not considered advisable. If the formation in cutting is met with black cotton soil, under reamed piles can be driven to achieve required track supporting capacity. The uncertainty about the under reamed pile capacity due to the low uplift capacity and due to the chance of breaking the unreinforced bulb portion, are to be managed by assuring with load test or by detailed designing to make less uplift load and by adopting fiber reinforced concrete for casting the pile. As

another measure to control the effect of slope, the wall will be cast with weep holes and boulder backing. The land sides can be cut in alternate sections to control the collapse of sides during construction and the formwork need to be made in slanting manner. The general arrangement is depicted in **Figure below**

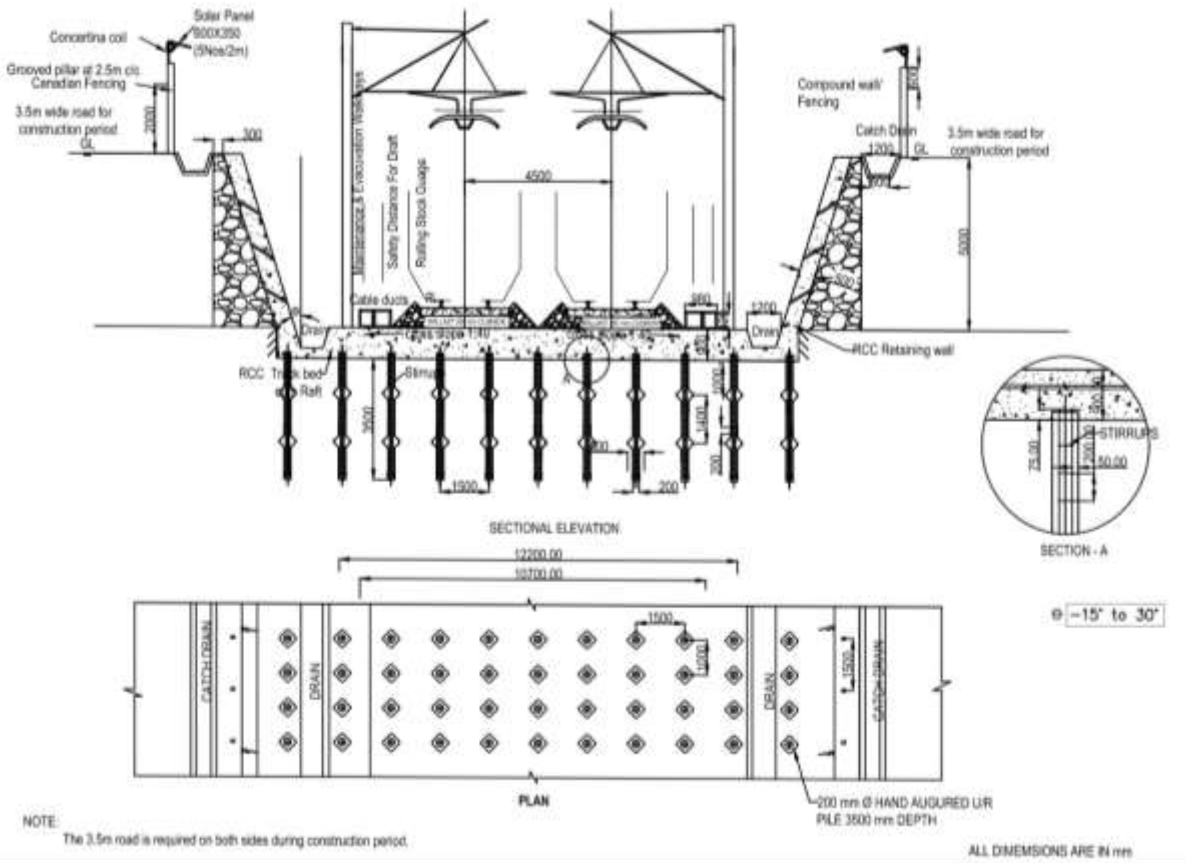



**Figure 8-93: Arrangement of Cut structure where formation soil is met with soil including black cotton having SBC<5 t/m$^2$**

### 8.12.3 Recommended Cross section of Cut Structures:-

Different types of possible cross sections of cut structure in the corridor are mainly discussed one by one in the following paragraphs. Among all types of cut structures, the Gabion wall reinforced with geogrid is found more economical and greener, and hence the same is considered for estimate purpose beyond 3m depth . In-situ/Precast RCC - cantilever type, retaining walls of each 1m length are also found economical and safe for height from 3m to 6m as shown in **Figure below**. Service road and corresponding surcharge load has been considered while arriving the dimensions in the drawing. Service road is must to get access to the houses on either side of cutting. The trolley refugees in cuttings are proposed at every 100m on either side of cutting. This can be made by excavating the soil across the sloping sides and by protecting the new sides with retaining

walls. Hence additional land for trolley refuge in cuttings is not required. Typical cross section for various depths are given as under;

**1) Typical cross section of Cut structures where land width is limited, and depth varies from 3 to 6m:-**

The stretches where land width is limited and depth of cutting required varies from 3 to 6m can be constructed with RCC retaining walls as shown in the **Figure below**;

;

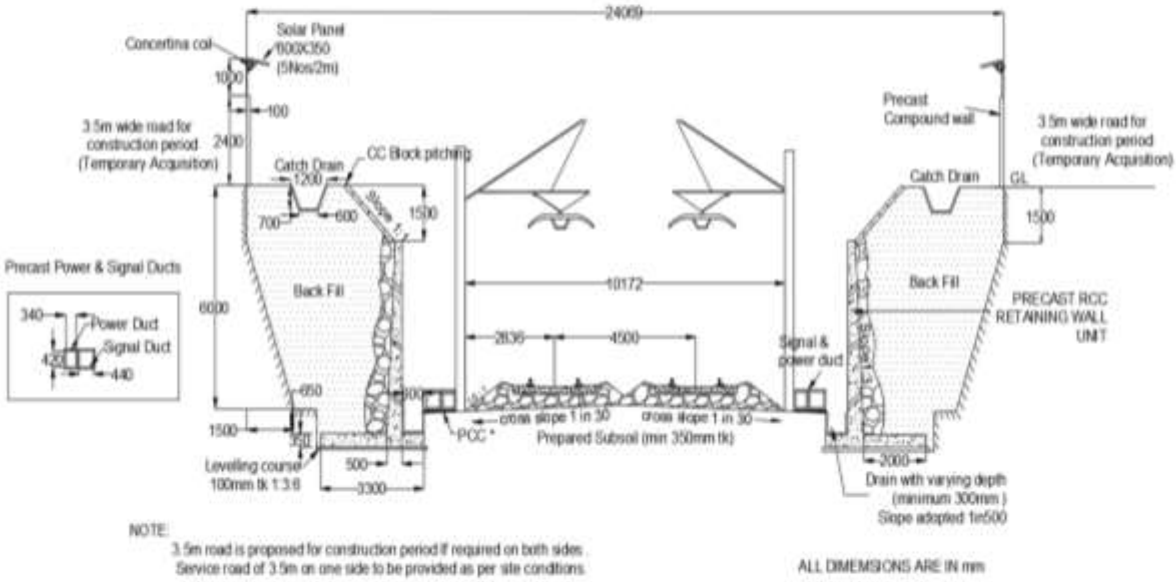



**Figure 8-94: Typical arrangement of cut structure with RCC retaining wall (3m-6m)**

**b. Typical cross section of Cut structures where land width is limited, and depth up to 9m:-**

The stretches where land width is limited and depth of cutting required is more than 6m and up to 9m can be constructed with RCC retaining walls and additional gabion walls at top portion as shown in the **Figure below**;

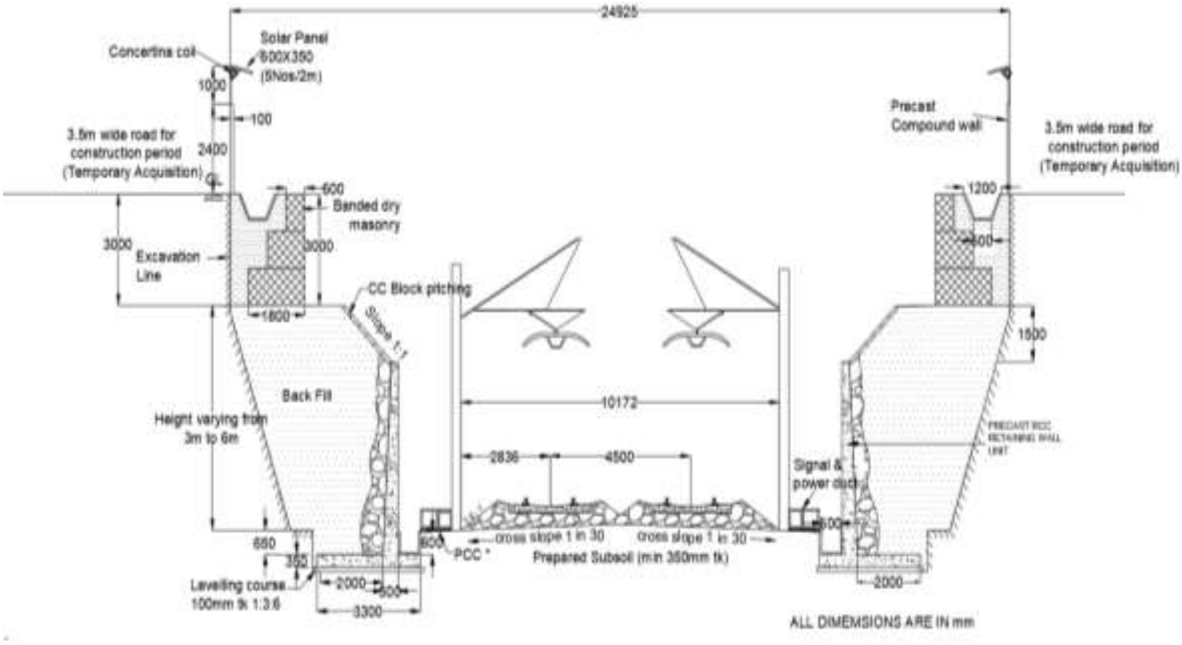



**Figure 8-95: Typical arrangement with RCC R/Wall and Gabion wall at top 3m (6-9m)**

## c. Cut structure- Without RCC retaining wall, where land is available, depth up to 6m

The stretches where land width is not limited and depth of cutting required varies from 0m to 6m can be made as usual as shown in the **Figure below**. Width of land required will be 25m up to 3m and 31m up to 6m.

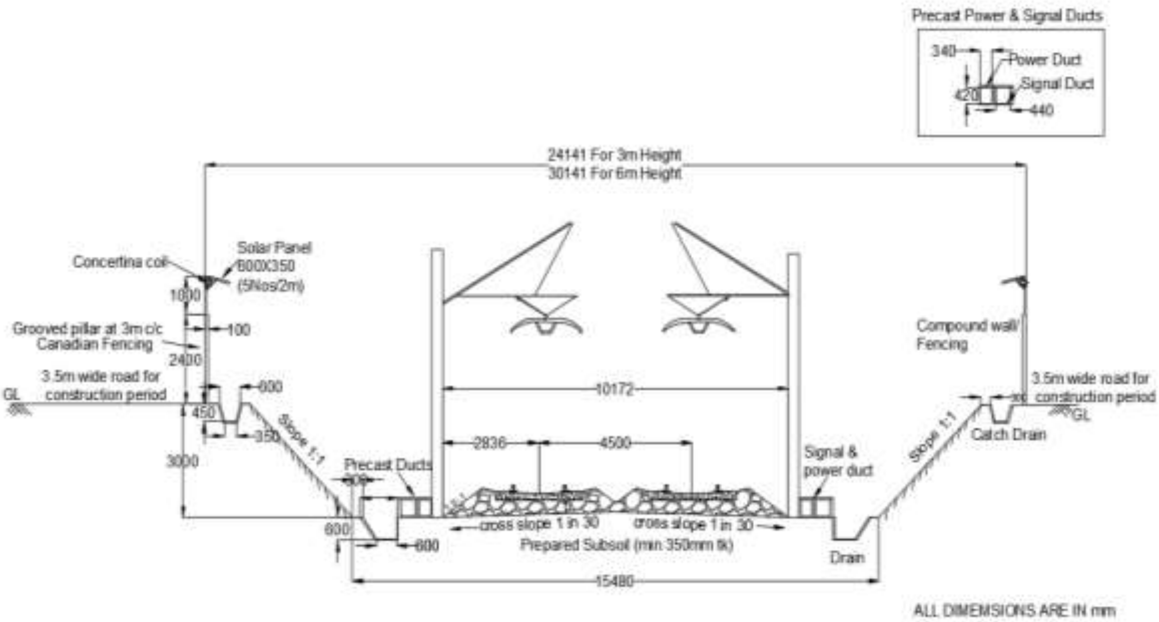



**Figure 8-96: Typical arrangement without RCC retaining wall (0-6m)**

d. **Cut structure- without RCC retaining wall, where land is available, depth up to 9m:-**

The stretches where land width is not limited and depth of cutting required varies from 6m to 9m can be made by providing a berm of width 3m as shown in the **Figure below**. The width of land required is 44m at the top of the cutting.

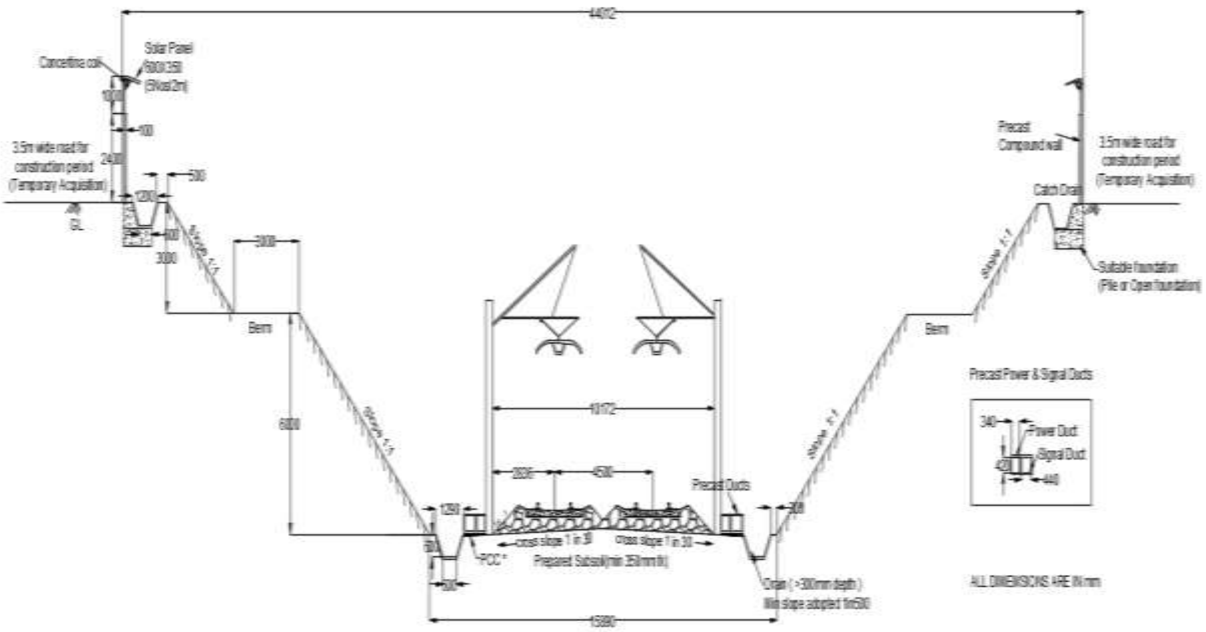


**Figure 8-97: Typical arrangement without RCC retaining wall (0-9m)**

**e. Gabion wall with geogrid reinforcement:-**

At some of the sections may need Geo synthetics which can also be used on slopes as slope protection measures as per site conditions.

The most economical as well as environment friendly solution for a cutting structure is gabion wall with geogrid reinforcement. The anchor length of geogrid reinforcement is 0.7H generally as per the RDSO guidelines. This can be minimized by providing more geogrid reinforcements after design. The sloping top of cutting will help to get more vertical surcharge. However, for getting maximum compaction to the backfill, it is important to avoid the rainy season for the compaction and construction.

This is one more equally adoptable solution for the stretches where land width is limited and depth of cutting required varies from 3 to 9m can be constructed with Gabion walls with geogrid reinforcement as shown in the **Figure below**;

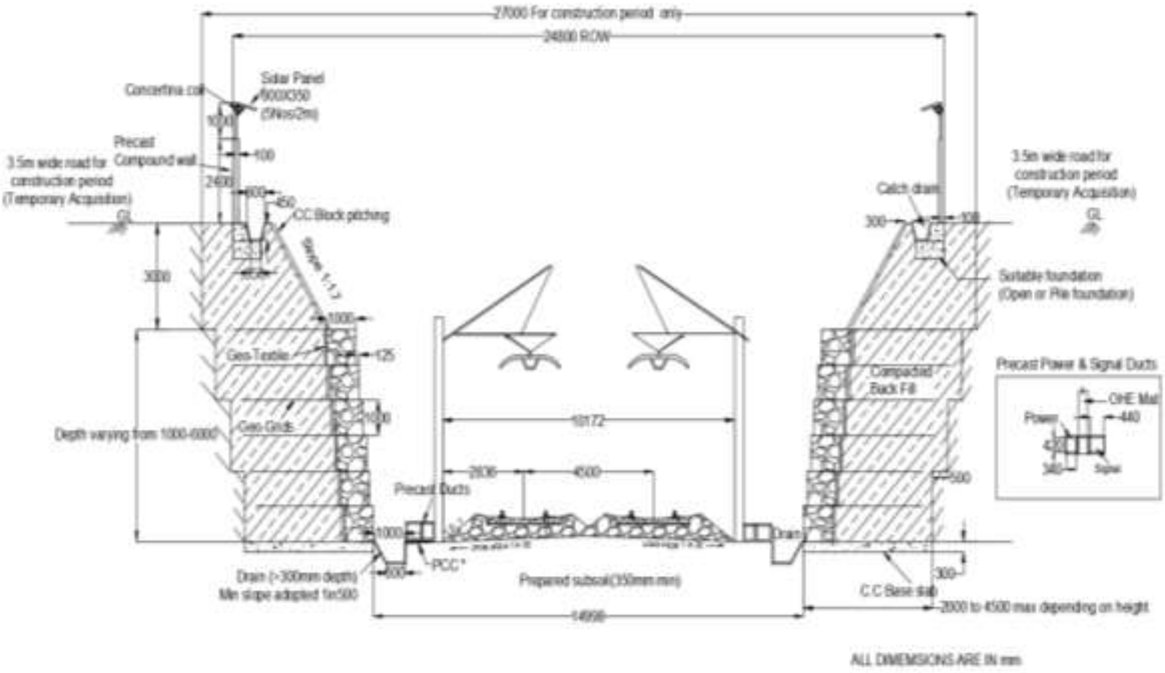



**Figure 8-98: Gabion wall with Geogrid reinforcement**

### 8.12.4 Additional requirements in cutting stretches:-

**1) Catch ditch:-**

Ditches are important tools for containing the detached rock mass so as to prevent them from reaching the track and creating obstruction over track. The slope, depth, width & storage volume are important factors in design of ditch. The choice of ditch geometry should also take into consideration the angle of slope that influences the behavior of falling rocks. The criteria that involve the height and angle of slope, depth of ditch and width of fallout area are given in table below. If the space is less than required, limited protection against small rolling rocks can still be provided inexpensively by excavating a catchment area or by installing a low barrier formed of gabions at the shoulder of the track.

**Table 8-24: Design Criteria for Catch Ditches**

| Slope | Height (m) | Fallout area width(m) | Recommended ditch depth(m) |
|---|---|---|---|
| Near Vertical | 4 to 10 | 3.7 | 1.0 |
| | 10 to 20 | 4.6 | 1.2 |

| Slope | Height (m) | Fallout area width(m) | Recommended ditch depth(m) |
|---|---|---|---|
| | >20 | 6.1 | 1.2 |
| 0.25 or 0.3:1 | 5 to 10 | 3.7 | 1.0 |
| | 10 to 20 | 4.6 | 1.2 |
| | 20 to 30 | 6.1 | 1.8* |
| | >30 | 7.6 | 1.8* |
| 0.5:1 | 5 to 10 | 3.7 | 1.2 |
| | 10 to 20 | 4.6 | 1.8* |
| | 20 to 30 | 6.1 | 1.8* |

** can be reduced to 1.2 m if a catch fence is used where there is space constraint.*

Where permanent benches are used to intercept falling rock, access should be provided for periodic removal of debris. The width of such benches may be decided on the basis of mechanical working after weathering of the softer rock has taken place. A minimum width of 5 to 6 m may be desirable.

In the SilverLine corridor, the cuttings on soft rock area, vulnerable for rock fall, are rare and if at all required, this can be prevented by providing wire nets for a controlled falling of rock. However, this can be reviewed at the time of execution

### 2) Side drains & catch water drains

A good drainage system speaks the health of cutting. Inadequate drainage on hill side causes softening of the sub-grade and renders it too weak to take the load of the moving traffic. Side drains are therefore necessary on hill side. Side drains are provided along the hill side for taking the surface run off to the nearest cross drain. These can be taken up for construction after stabilization of hill slopes to some extent. These drains should be lined as the water flow is likely to erode the bed and sides of the drain.

Side drain width is generally 1.2 m wide on top, 0.6 m at bottom. The depth is min 0.3 m, with deeper drains as per longitudinal slope depending upon length of cutting. Sub-

surface longitudinal drains may be required where blanket layer has been provided as shown in **Figure below.**

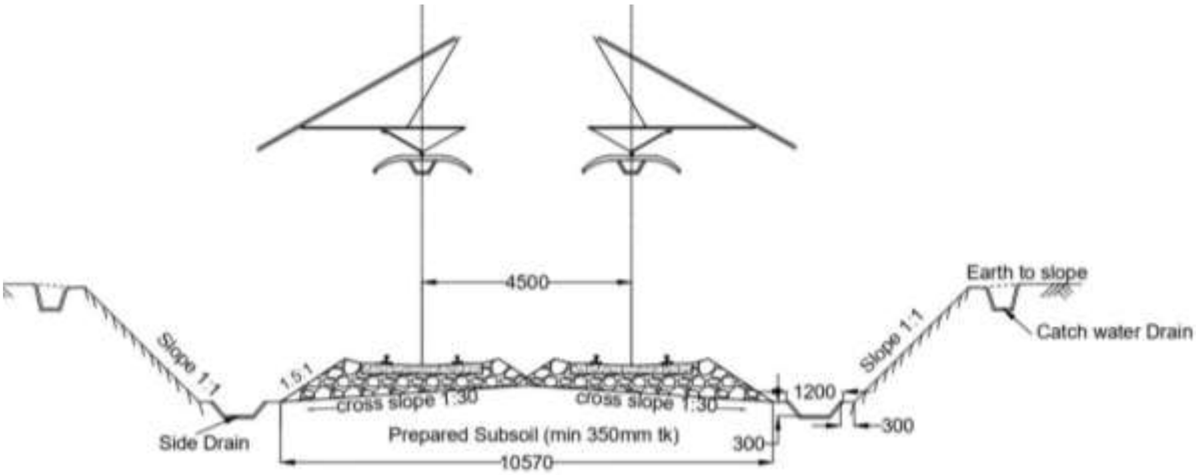



**Figure 8-99: Typical cut section with side and catch water drain**

- **General notes:-**

1. Catch water drains shall be provided on the natural ground if formation in cutting is likely to get flooded from surface water flowing across the cutting or when depth of cutting is more than 4m.
2. All catch water drains shall be pucca. The expansion joints shall be sealed with bituminous concrete.
3. The catch water drains shall have section enough to carry 50% more than the required discharge to cater for any blockade or silting.
4. Catch water shall have adequate slope to ensure development of self-cleansing velocity.
5. Catch water drain shall have well designed outfall with protection against tail- end erosion.
6. Catch drain shall not have any weep hole.

In the above paragraphs, both embankment and Cutting structures for the SilverLine corridor have been discussed elaborately. However, the safety of these structures has to be viewed seriously to avoid any unforeseen occurrences causing stopping of trains. If the subsoil is of poor strength, there are chances of such events. Hence, it is obvious to discuss the various ground improvement techniques in detail which are discussed below, in the following paragraphs.

## 8.13 GROUND IMPROVEMENT TECHNIQUES METHODS:

In view of the characteristics of the soil reported from soil investigations done at every 5 Km interval along the alignment as discussed above, there is a need of adopting ground improvement techniques at some of the places where the SBC of soil is below 15 t/m$^2$ particularly some stretches between Trivandrum and Ernakulam like in Kudoor area, river approaches, and marshy areas, etc.

The ground improvement techniques can be adopted to improve the ground strength on which the embankment/fills are constructed. The underlying soil for fill is required to satisfy the same basic requirements of a continuous spread foundation system. The underlying soil should have the strength to support the proposed embankment and live loads with an adequate safety factor. In addition, the embankment/fill needs to be designed and constructed such that it can tolerate the projected degree of settlement. It is occasionally necessary to remove and replace portions of weak or highly compressible underlying soil or to improve their characteristics by using stabilization procedures or controlled construction techniques. Identification of vulnerable conditions of ground which requires improvement can be measured in terms of high content of soft clay having undrained shear strength less than 25 kPa, loose sand strata having N value less than 5, and Ev2 (Elastic Modulus of 2nd plate load test) assessed less than 20MPa. Controlled construction techniques could include one or combination of the following measures which have to be reviewed during execution as per advice from the DDC:

### 1) Removal and replacement of weak soil:-

For localized areas with soft soils (having undrained shear strength less than 20 kPa or CBR<3) of limited depth and thickness, removal of unsuitable material and replacement with suitable fill may be carried out. These unsuitable materials were encountered in valleys and low-lying areas and may be replaced with well-compacted suitable fill preferably coarse-grained/sandy soils. Excavation and replacement could be carried out up to 2 m. The removal and replacement may be required to be carried out even in ‘cutting’ areas where the naturally occurring soils were found to be of a low shear strength and high moisture content. Subsurface drainage may have to be introduced in most of such areas.

### 2) Stage construction of the fill:-

This technique can enhance the bearing capacity of the sub-soil and provide the site for required construction of embankment up to the design height in the phases/stages with a designed strength of the soil & calculated waiting period for the next loading upon the previous loading.

Stage construction is employed mainly as a means of gradually increasing the shear strength of a soft clay which would otherwise be inadequate to carry the intended

embankment load without failure. In stage construction, advantage of increase in shear strength of sub-soil strata due to consolidation by surcharge of embankment loading is considered. The gain in shear strength is a function of angle of shearing resistance improved in terms of effective stress parameters and degree of consolidation.

**3) Preloading and surcharging:-**

The preloading technique is a simple one and is an economical method for accelerating consolidation as compared with other methods of improving ground support. However, adequate instrumentations for monitoring the settlements, development and dissipation of pore water pressures is essential for the success of this technique. Preloading is particularly economical technique in the construction of railway fills on soft clays, since, the material can stay in place and needs not be relocated.

For low embankment over soft compressible soil where the poor ground is of limited thickness (short drainage path) or can compress rapidly under load of excess preload fill due to presence of sand lenses, preloading may be resorted. Preloading of soft soils is based on the consolidation concepts; whereby pore water is squeezed from the voids until the water content and the volume of the soil are in equilibrium under the loading stresses imposed by the surcharge. This is usually accompanied by gain in shear strength of soil. To a certain extent, the primary consolidation under final loading can be achieved during construction and hence post construction settlement reduces.

**4) Installation of vertical drainage system:-**

Vertical drains are used where preloading alone shall not be efficient. Vertical drains in soft clay accelerate the primary consolidation of clay since they bring about rapid dissipation of excess pore water pressure. Vertical drains have no direct effect on the rate of secondary compression, but the early completion of primary consolidation brings about the earlier onset of secondary settlement. Therefore, the structures or embankments can be put to use earlier than it would be possible otherwise.

The accelerated rate of gain in shear strength of clay enables the loads to be applied more rapidly than would otherwise be possible. Steep side slopes and avoidance of berms in case of embankments may be possible when sand drains are used. The effectiveness of vertical drains depends mainly on the engineering properties of soils, namely, soil permeability and coefficient of consolidation and their variations in space and time. Vertical drains can be successful in accelerating the rate of consolidation of soft fine-grained soils. These however may be ineffective in organic soils and highly stratified soils.

Generally, the drains are installed by any of these methods depending upon the site conditions and availability of equipment.

Prefabricated vertical PVC drain can be defined as any prefabricated material or product consisting of a synthetic filter jacket surrounding a plastic core. Because of their shape, they are also known as band or wick drain. The details of PVC drains and their installation techniques are given in “Prefabricated PVC Vertical Drainage System for Construction of Embankment on Compressible Soft Soil” RDSO Report No. GE-R-68, December 2004.

**5) In-Situ Pile/Sand Gravel Compaction Pile/ Stone Columns:-**

Granular piles are composed of compacted sand or gravel installed into the soft clay foundation by displacement method. The term ‘granular piles’ used refers to these components of compacted gravel and/or sand piles. It is also known as stone columns. The ground improved by compacted granular piles is termed as composite ground. On loading, the pile bulging into the sub-soil strata and distributes the stresses at the upper portion of the soil profile rather than transferring the stresses into the deeper layer, thus causing the soil to support it.

As a result, the strength and bearing capacity of the composite ground can be increased and the compressibility reduced. In addition, lesser stress concentration is developed on the granular piles. The granular/sand material with higher permeability, these piles could accelerate the consolidation settlement and minimize the post construction settlements.

Stone columns provide path for pore pressure reduction and lateral confinement of soft clay layers, bearing capacity is greatly enhanced, and may be provided in areas where subsoil layers consists primarily of saturated soft clay more than about 3 to 5 m thick and where the required stringent consideration of settlement cannot be satisfied with conventional removal / replacement of soft material. After Stone column treatment, the embankment with non-compressible fill can be constructed to its full height continuously without further stage construction.

**6) Vibro-floatation :-**

Various methods referred for installation of Granular piles have been used all over the world depending on their proven applicability and availability of equipment in the locality. This technique is versatile with respect to range of soils to which it has been applied through soft to firm clays, silts, sands and gravels to brick rubbles and essentially

inorganic rubbish. The Vibro-floatation contains an eccentric weight mounted at the bottom on a vertical shaft, directly link to a motor in the body of the machine. The vibrating motion is thus horizontal with the body cycling around a vertical axis. Vibratory energy is applied directly to the ground through the tubular casing of the machine and output remains constant whatever be the depth of penetration.

**7) Lime Pile:-**

It is a kind of vertical drains used where preloading alone will not be efficient. Such drains in soft clay accelerate the primary consolidation of clay since they bring about rapid dissipation of excess pore water pressure. Extensive laboratory studies on the use of lime-stabilized piles have been carried out at the Asian Institute of Technology. Additional of 5 to 10% quicklime is the optimum mix proportions for the soft clay. The addition of quicklime increased the unconfined compressive strength to about 5 times and increased the pre-consolidation by as much as 3 times. The coefficient of consolidation also increased by 10 to 40 times and the effective strength parameters also increased, especially the angle of internal friction from 24 degree to 40 degree.

**8) Lime Slurry Pressure Injection/ Ion Exchange:-**

This is the treatment of expansive clays with lime has been found to be effective in reducing the shrinking and swelling characteristics and increasing their shear strength. This may be done in two ways, one by making a bore hole in the ground on Railway formation top to the required depth and then filling the bore hole with the dry lime and then to pour water on the lime filled bore daily for some days, so that lime is carried along with the water into the soil seams or voids and thereby improving the properties by replacing the exchangeable cat ions of sodium, Magnesium and Potassium etc.; The strongly +ve charged ions of calcium present in lime replace the weaker ions of sodium (Na),Magnesium (Mg), and Potassium (K) etc.; present in the soil.

The second method is by injecting lime/ cement slurry under pressure in a pre-driven hole. The slurry spreads into voids or seams of the surrounding soil structure, forming a network of thin seams of dense lime which overlap. Injection of lime slurry is normally done during dry months of the year when the moisture content of the soil is minimum.

The increase in strength and decrease in compressibility of soft ground results from the reaction of clay with lime and/or cement through the processes of ion exchange and flocculation as well as pozzolanic reactions. The addition of salt, NaCl, may act as catalyzer and the ions Cl minus, Na plus, Mg 2plus may have accelerated the pozzolanic

reaction which is responsible to neutralize the net negative surface charge of each clay mineral reducing the size of double layer, and thus, increasing the attraction of clay particles leading to improve the ground.

**9) Stir & Mixing:-**

Lime/ cement mixing method can be used to improve the properties of soils since olden times. Deep stabilization of soft soils with lime and/or cement stabilized columns has been the subject of research in Sweden, Japan, and other countries for a very long period. The deep mixing (DMM) method originally was developed to improve the soft ground for port and harbor structures. Now this method widely applied to the earthen structures like dams, embankments etc. This method (DMM) may be classified into two categories as under: a) Mechanically mixing method and b) Slurry jet mixing Beside these two one more and effective methods cum practice is also popular that is Dry Jet Mixing method (DJM). In this method, the cement or quicklime powder is injected into the deep ground through a nozzle pipe with the aid of compressed air and then the powder is mixed mechanically by rotating wings. This type of prepared material can increase the unconfined compressive strength of improved soil in-situ by 400kpa at 28 days curing.

**10) Sand Mat:-**

It is a method in which dissipation of excess water from the soft soils by the means of vertical sand drains, horizontal sand drains and the provision of the sand layer at the ground level to improve the bearing capacity as well as the drainage of excess water which is responsible for increasing the pore water pressure within the soil mass.

Sometimes, when fill material of the embankment is also of poor-quality required sand layers of 30cm thick at the interval of 2-3m known as the sandwich construction. This type of construction improves the ground as well as the fill conditions and enhances the slope stability and the strength of the embankment in terms of cohesion.

**11) Stabilization & Ground Improvement Methods Using Geosynthetics:-**

Stabilization & Ground improvement techniques using geocell and load transfer platforms, at various locations in the track superstructure are proven to be effective in improving the performance of tracks on soft soils.

Following sections describe the different methods that are currently employed and are in practice to tackle various geotechnical problem on soft soil.

**a) Geocell:-**

To construct embankments on soft soil with inadequate bearing capacity geocell mattress is a unique method of ground improvement. The incorporation of a geocell foundation mattress provides a relatively stiff foundation and maximizes the bearing capacity of the underlying weak soil. The geocell mattress technique is particularly effective with relatively thin soft foundation layers where the ratio of embankment width to depth of soft soils is greater than four.

The geocell foundation mattress is a honeycombed structure formed from a series of interlocking cells. These cells are fabricated in-situ directly on the soft foundation soil using geogrids which are filled with granular material / locally available infill material. Further, when filled with suitable granular materials, geocell acts as a drainage blanket and can be used in conjunction with prefabricated vertical drains to accelerate consolidation.

Geocell is constructed using biaxial and uniaxial geogrids as described below;

The incorporation of geocell mattress creates an embankment foundation with the following characteristics

1. A perfectly rough interface between the mattress and the soft foundation due to the granular fill material partially penetrating the base geogrid layer.
2. A stiff platform to ensure both an even distribution of load onto the foundation and the formation of a regular stress field within the foundation.

**b) Load Transfer Platform:-**

The use of stone columns/ piles allows transferring the load of the embankment to the firm stratum below. As a process, the load from the embankment must be effectively transferred to the columns to prevent punching of the columns through the embankment fill creating differential settlement at the surface. Further to achieve soil arching the columns are placed closely for effective load transfer. In order to increase the spacing of columns, to minimize the size of pile caps required to support the embankment and to increase the efficiency of the design, a load transfer platform (LTP) reinforced with geosynthetic reinforcement is used. A load transfer platform consists of one or more layers of geosynthetic reinforcement placed between the top of the columns and the bottom of the embankment.

- **Design of LTP:-**

The design of column supported embankments must consider both limit state, and serviceability state failure criteria. The limit state failure mode includes pile group

capacity, pile group extent, vertical load shedding, lateral sliding and overall global stability. In addition to limit state analysis, serviceability state designs i.e. strain in the geosynthetic reinforcement and the settlement of the columns should be considered. The strain in the reinforcement used to create the load transfer platform should be kept below maximum threshold to prevent unacceptable differential settlement at the top of the embankment. Settlement of the columns must also be analyzed to assure that unacceptable settlement of the overall system does not occur.

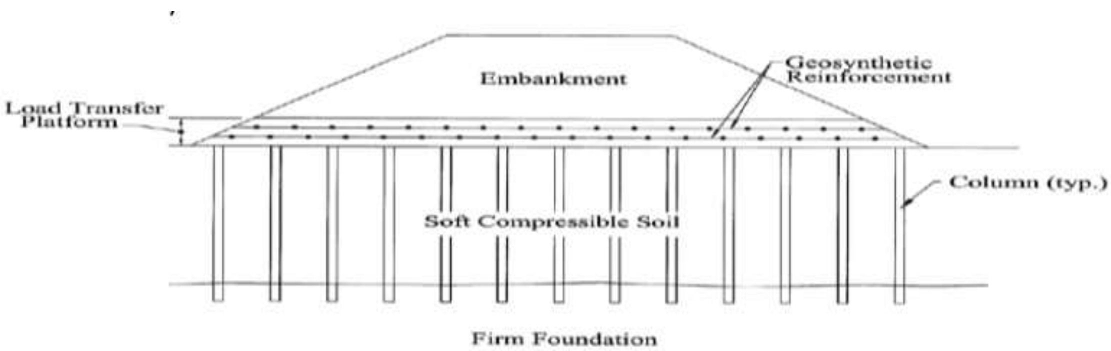



**Figure 8-100: Schematic Sketch of a Load Transfer Platform**

**c) Condition of loose stratum can be improved by means of grouting / geosynthetics:-**

There are some more ground improvement techniques prevalent and can be adopted for SilverLine project where the stretches are met with loose stratum. These are discussed hereunder;

- **Grouting:-** It may be used for filling voids to prevent excessive settlement, to increase allowable pressure of soil both for new structure as well as existing structure, densification of loose soil particles etc. by adopting following means of grouting: -

➢ Permeation grouting using particulate grout or chemical grout
➢ Jet grouting
➢ Hydro fracturing
➢ Compaction grouting

- **Geosynthetics:-** The structural stability of the soil is greatly improved by the tensile strength of the geosynthetic material. This concept is similar to that of reinforcing steel to the concrete. Since concrete is weak in strength & tension, reinforcing steel

is used to strengthen it. Geotextile materials function in a similar manner as the reinforcing steel by providing strength that helps to hold the soil in place. Strength created by the introduction of geotextile into the soil & developed primarily through the following three mechanisms: -

- Lateral restraint through interfacial friction between geotextile and soil/aggregate.
- Forcing the potential bearing surface failure plane to develop at alternate higher shear strength surface.
- Membrane type of support of the wheel load.

Following categories of Geosynthetics may be used for improving structural stability of soil. This is however to be reviewed during Execution and use as per site suitability.

**Table 8-25: Categories of Geosynthetics**

| S. No. | Categories | Description | Applications |
|---|---|---|---|
| 1. | Geomembranes | These are impermeable polymeric sheets used as carrier for liquid or solid waste containment. | Land fill lining, Canal lining, Tunnel lining |
| 2. | Geosynthetic clay liners | Prefabricated bentonite clay layers incorporated between geotextile and geomembrane and used as a barrier for liquid or solid waste containment. | Canal lining, Tunnel lining |
| 3. | Geopipes, Geo-composites | Hybrid systems of anyor all the above geosynthetics types which can function as specifically designed for use in soil, rock, waste and liquid related problems. | Composites of two different types of Geosynthetics to take advantage of each |

## 8.14 UNDER GROUND STRUCTURES:

The main structures coming under this group are Cut & Cover and Tunnel. These structures are discussed in the following paragraphs.

### 8.14.1 Cut & Cover:-

For stretches with deep cuttings more than or equal to 9m and up to 20m, cut and cover construction method is considered with RCC box of inner clear dimension of 12.00 m x 8.00 m (with ballast-less track) in the portion of the tunnel and 13.25 m x 7.50 m (with ballasted track) in the continuing portion of the cutting, as cast- in -situ at the required level.

Land width requirement is less, and land use is efficient in case of cut and cover. Cutting over cover shall not be left unprotected and drainage over cover in cutting is very important. Top of back filled ground can be pitched with CC blocks by providing suitable slopes to drain surface water immediately. Safety of personnel while working in such a zone is of primary concern as many cases of workers buried alive due to caving in have occurred. Diaphragm wall with ground anchors is proposed in all such constructions.

**1. Proposed Cross sections of Cut & Cover:-**

A typical top-down construction to cast RCC box with the help of Diaphragm walls and Steel bracing during construction, suitable to adopt after cutting is depicted in **Figure below**;

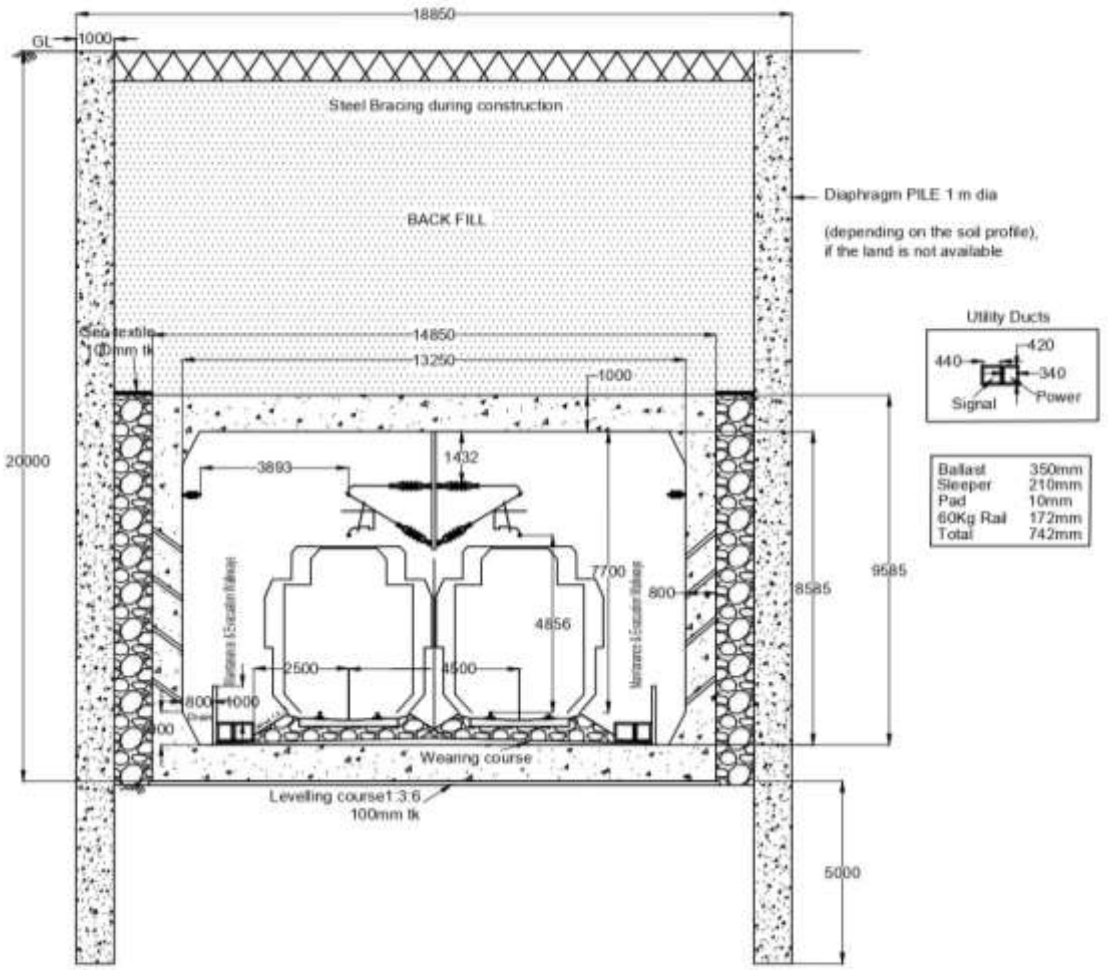



**Figure 8-101: Cut & Cover structure before and after Cutting**

2. A similar top-down profile with curved box profile is shown in **Figure below.**

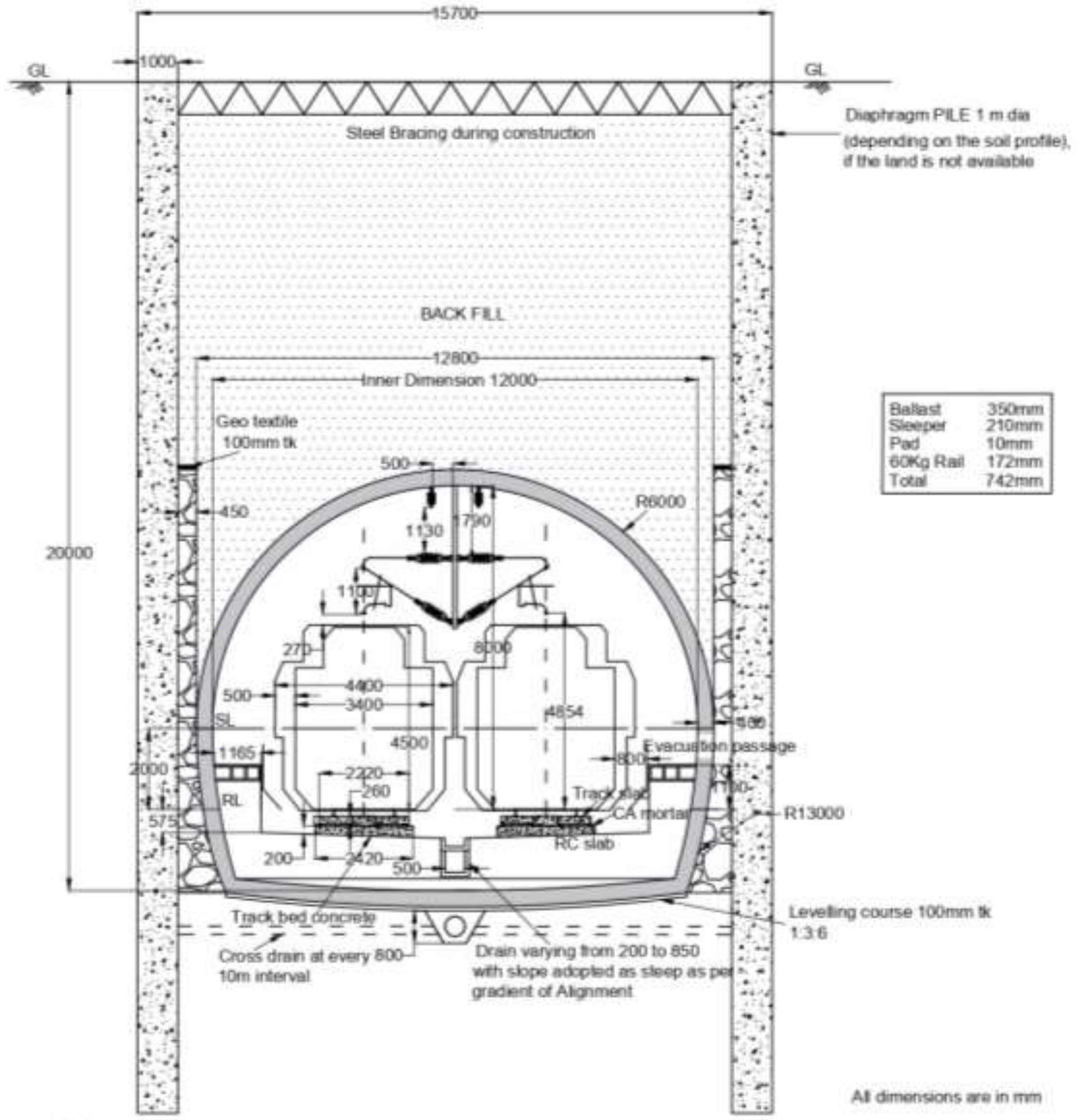



**Figure 8-102: Cut & Cover structure before and after Tunnel**

The above Figure 8-102 is to be adopted after and before the tunnels, where cutting depth exceeds 9m and is less than 20m.

### 8.14.2 Tunnel:-

#### 8.14.2.1 General:-

A tunnel is an underground passageway, dug through the surrounding soil/earth/rock and enclosed except for entrance and exit, commonly at each end. This is the costliest underground structure and hence to be provided only at unavoidable locations in the SilverLine corridor. For SilverLine project, tunnels have been proposed on unavoidable locations only where the cutting is more than 20m deep with adequate cushion.

The provision, its design and the construction method of Tunnel will depend on the Geology and soil report of the area. TBM or NATM procedure is adopted depending on the results geological surveys on close intervals and other detailed surveys which will be carried out during actual execution in detail. However for short length of the tunnels on SilverLine corridor the best and suitable method is NATM but the location where the alignment is proposed with long length tunnel like in Calicut, TBM option can be explored due to the need of high quality construction of tunnel passing through the river and the city area. TBM is more economical when the length of the tunnel is more and continuous.

#### 8.14.2.2 Types of Tunnels:-

The tunnels are classified generally as described below;

**(1) Mountain Tunnel :-**

A mountain tunnel is a tunnel which is excavated to cross the hillocks to lay the tracks penetrating the mountains. Making the glade of the tunnel in a reversed V shape, that is, making the middle part of the tunnel higher and making the both ends lower, enables natural drainage. Totally 4 numbers of mountain tunnels have been proposed for SilverLine project.

**(2) Urban Tunnel:-**

Urban tunnel is a tunnel which runs in the built up area under different structures. In various cities of India underground metro are urban tunnels. One such tunnel has been envisaged for SilverLine project in Kozhikode. As this tunnel is passing under the river Kallayi and is close to the sea, special protection arrangement to prevent seepage and well designed drainage system will be required.

**(3) Underwater Tunnel:-**

Underwater tunnels are a tunnel which is excavated below the riverbed or seabed. This type of tunnel requires mechanical drainage because its midsection needs to be structurally lower than other section.

#### 8.14.2.3 Location of the tunnels

The location of the tunnels proposed in the alignment are shown in the **Table 8-26**. Depending on the point where they are constructed, tunnels are normally classified into two. One is the mountain tunnels and the other urban tunnels. In this project both types of tunnels are planned to cross the hillocks and the city and river like in Calicut.

**Table 8-26: List of the locations where tunnels are proposed**

| S.No. | Chainage from (km) | Chainage to (km) | Length (km) | Type of tunnel | Remarks (No of Tracks, Shape, Cut & Cover length in km as tunnel continuation) |
|---|---|---|---|---|---|
| 1 | 33.700 | 34.000 | 0.300 | NATM | For double track & Horseshoe shape, Approaches Cut & Cover length 0.218+ 0.135 m |
| 2 | 34.850 | 35.350 | 0.500 | NATM | --Do--, CT & CVR 0.166+0.80 |
| 3 | 40.200 | 40.400 | 0.200 | NATM | --Do--G74, CT & CVR 0.03+0.08 |
| 4 | 100.600 | 101.400 | 0.800 | NATM | --Do--, CT & CVR 0.050+ 0.150 |
| 5 | 134.000 | 134.150 | 0.150 | NATM | --Do--, CT & CVR 0.050+0.075 |
| 6 | 156.250 | 156.600 | 0.350 | NATM | --Do--, CT & CVR 0.025+0.080 |
| 7 | 158.000 | 158.400 | 0.400 | NATM | --Do--, CT&CVR 0.05+0.05 |
| 8 | 161.130 | 161.400 | 0.270 | NATM | --Do--, CT & CVR 0.055 + 0.026 |
| 9 | 164.000 | 164.400 | 0.400 | NATM | --Do--, CT & CVR 0.023 + 0.070 |
| 10 | 170.850 | 171.230 | 0.380 | NATM | --Do--, CT & CVR 0.070+0.020 |
| 11 | 173.395 | 173.995 | 0.600 | NATM | --Do--, CT & CVR 0.140+0.070 |
| 18 | 354.946 | 360.160 | 5.214 | NATM + TBM | Double+ Single tracks, --Do-, CT & CVR 0.750+0.710 |
| 20 | 467.796 | 469.760 | 1.964 | NATM | --Do--, CT & CVR 0.110+0.020 |

### 8.14.2.4 Geological Aspects:-

Geological aspects are to be seen and studied in detail to design and construct the tunnels as required to be constructed as per alignment design needs for the project. Critical review is required during execution stage by detailed soil and other geological investigations and detailed Ground water investigation. GFC design, type of tunnel and its shape will be ascertained accordingly. Construction methodology will be affirmed accordingly before execution whether to do it by NATM and TBM or both.

### 8.14.2.5 Considerations in Tunnel Design:-

The choice of the tunnel system is based mainly on operational, organizational and safety considerations which is true for long tunnels. The choice of alignment is controlled by the ruling gradient inside the tunnel which is 75% of the ruling gradient in the open track. Other controlling factors are;

- Permitted max. deg. of curve
- The drainage considerations during construction and operation
- The accessibility during natural hazards in the portal areas.
- The ground conditions

The Shape and Dimensions of the Cross Section is determined essentially by;

- The serviceability requirements associated
- The geological- geotechnical condition
- Construction aspects.
- Additional space requirements for cable installations, signaling system, lighting, ventilation, etc.
- Aerodynamic requirements.
- Drainage requirements.
- Maintenance requirements.
- Escape facilities.
- The geo-technical conditions determine the required supporting system in the construction stage and the required permanent lining in the service stage.
- The construction methodology is selected based on economic aspects and availability of equipment.

### 8.14.2.6 **Various shapes of tunnels suitable for Railways**

**1. Horseshoe cross section:-**

The horse-shoe shape has a semi-circular roof together with arched sides and curved invert. This cross-section offers a good resistance to external ground pressure and is suitable for soft rocks.

**2. Circular cross section:-**

This shape is strong in resisting external pressure caused by water, water bearing soils or soft grounds. This is the best theoretical section for resisting internal or external forces and it provides the greatest cross-sectional area for the least perimeter. The circular section is often uneconomical for railways as more filling will be required for obtaining flat base. It is best suited for tunnels driven by the TBM/ shield method.

#### 8.14.2.7 Choice of TBM or NATM:-

The tunnels are broadly classified into Mountain tunnels and urban tunnels depending on their location. Mountain tunnels are normally constructed by the New Austrian Tunneling Method (NATM) developed in Austria as suggested by its name to use sprayed concrete and rock bolts as supports to effectively utilize the hollow space holding capacity, thereby ensuring the safety of tunnel. When compared with conventional tunnel constructing method, it reduces the number of supports to hold the tunnel bore space, thereby substantially cutting the construction cost.

In contrast, urban tunnels are normally constructed, by the cut and cover method, TBM and NATM. The cut and cover tunneling method is often used to construct large-scale underground stations or the short tunnels close to cutting locations. The shield tunneling method is mostly used to construct tunnels between stations. It is also being used to construct underground stations in recent years

#### 8.14.2.8 Methods for Tunnel Constructions:-

**Selection of the tunnelling methods is done keeping following objectives in considerations;**

- Geological conditions of the strata
- Whether urban tunnel or mountain tunnel
- Vicinity of waterbodies, lakes, rivers or sea
- Types of buildings and their conditions
- Quality of construction and timeline
- Minimization of the surface settlement to maintain all metropolitan activities without adverse affect
- Expeditious tunnel execution to minimize duration and space of the surface effects due to tunnelling.
- Economy in tunnelling costs.

Mainly two methods, NATM and TBM are in vogue for construction of the Tunnels. These are elaborated hereunder one by one in subsequent paragraphs;

**1. Tunnel Boring machine (TBM):-**

To achieve the objectives as mentioned above in para Methods for tunnel constructions, the use of Tunnel Boring Machine (TBM) is the prime method of tunneling. Locations where deployment of TBM is not possible (tunneling of short length, cross passages, underground stations which are not possible by cut and cover method etc.) are tackled by NATM method.

**Selection of type of TBM machine:-**

Choice of appropriate TBM depends upon the detailed geological studies and soil conditions. In the rocky strata, heavy disc cutters are required in the cutter head, whereas for excavating soft soils, scrappers are provided in the cutter head. In mixed soil conditions, the TBM should be capable of excavating soils and rocks both, hence combination of scrappers and disc cutters is used under such situations.

The most important issues to be addressed in selecting a Shield tunnelling method is face stability and minimum displacement/ settlement of ground and structures confronting suitable TBM in this project will be the closed type. The Closed type TBM is further categorized as Earth- Pressure Balanced (EPB) TBM and Slurry type TBM. EPB is further categorized into Earth-pressure type TBM and Mud-pressure type TBM.

- **Earth-pressure type TBM:-**
  The Earth-pressure type TBM is suitable for certain types of soil that can be directly fluidized. Fluidized soil fills the cutter chamber and the screw conveyor is used for discharge of muck, thereby keeping the cut face stable. The shield machine is able to simultaneously excavate soil during shield advance, so not only is the face well stabilized, but also the effects on the surrounding ground are minimized.

- **Mud-pressure type TBM:-**
  The Mud-pressure type TBM is that soil pressure at the face is transferred efficiently to ground that is high in sand content and low in fluidity through the addition of water, mud, and additives. It is applicable to a large range of soils, including soft ground with low solidity such as alluvial sand/gravel, sand, silt and clay, alluvial deposits, and alternating hard and soft soil layers. The only limitation is that the soil discharge screw conveyor is unable to operate when the ground has high hydrostatic pressure. For this reason, it is necessary to closely study the soil properties before implementation.

- **Slurry type TBM:-**
  Slurry type TBM (Air tunnel-boring machine) is used for tunnel-boring in highly permeable unstable terrain, or under civilian structures sensitive to ground disturbances.

When digging in highly unstable or liquid terrain, the pressure exerted by the terrain is directly governed by the depth at which digging is performed. It is therefore necessary to

balance the pressure exerted by the terrain: the front shield of the Slurry TBM is filled with excavated material, with the exception of one air-filled part. The pressure within this air bubble is subject to fine control. Bentonite injection waterproofs the working face and improves its resistance.

**2. New Austrian Tunneling method (NATM):-**

The New Austrian Tunneling method (NATM) was developed between 1957 and 1965 in Austria. It was given its name in Salzburg in 1962 to distinguish it from old Austrian tunneling approach. The main contributors to the development of NATM were Ladislaus von Rabcewicz, Leopold Müller and Franz Pacher. The main idea is to use the geological stress of the surrounding rock mass to stabilize the tunnel itself.

NATM is a tunneling method that sprays concrete or uses rock bolts with lattice girders to control deformation during excavation of the ground. It is also useful when the soil strata are the mixed with soft soil and the boulders.

- There are following features on which NATM is based;

a. Mobilization of the strength of rock mass – The method relies on the inherent strength of the surrounding rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.

b. Shotcrete protection – Loosening and excessive rock deformation must be minimized. This is achieved by applying a thin layer of shotcrete immediately after face advance.

c. Measurements – Every deformation of the excavation must be measured. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground, and boreholes.

d. Flexible support – The primary lining is thin and reflects recent strata conditions. Active rather than passive support is used, and the tunnel is strengthened not by a thicker concrete lining but by a flexible combination of rock bolts, wire mesh and steel ribs.

e. Closing of invert – Quickly closing the invert and creating a load-bearing ring is important. It is crucial in soft ground tunnels where no section of the tunnel should be left open even temporarily.

f. Contractual arrangements – Since the NATM is based on monitoring measurements, changes in support and construction method are possible. This is possible only if the contractual system enables those changes.

g. Rock mass classification determines support measures – There are several main rock classes for tunnels and corresponding support systems for each. These serve as the guidelines for tunnel reinforcement.

h. Based on the computation of the optimal cross section, just a thin shotcrete protection is necessary. It is applied immediately behind the Tunnel boring machine, to create a natural load-bearing ring and therefore to minimize the rock's deformation. Additionally,

geotechnical instruments are installed to measure the later deformation of excavation. Therefore, a monitoring of the stress distribution within the rock is possible.
Different tunnel boring methods are shown in the pictures **Figure below**;

**Figure 8-103: Different tunnel boring methods**

### 8.14.2.9 Tunnel shapes and the method of constructions proposed in different projects:-

Comparison of Tunnel shapes and the method of construction adopted in different projects all over India is shown in the **Table 8-27**;

**Table 8-27: Comparison Of Tunnels Adopted In Various Railways**

| Sl no | Project | Single track/ Double track | Tunnel area above Rail level in $m^2$ | Method of Construction | Remarks |
|---|---|---|---|---|---|
| 1 | MUM- Ahmedabad (HSR | Double | 80 | NATM | HSR |
| 2 | RRTS- Delhi | Single | 33.18 | TBM | Max.180 Kmph |
| 3 | KHSR (FR) | Double | 80 | NATM | HSR |

| Sl no | Project | Single track/ Double track | Tunnel area above Rail level in $m^2$ | Method of Construction | Remarks |
|---|---|---|---|---|---|
| 4 | Proposed for SILVERLINE | Double | 80 | NATM for mountain tunnels (short tunnels), TBM or NATM for Calicut urban tunnel | Max. Design speed 200Kmph/ 250 Kmph for tilting trains |

#### 8.14.2.10 Recommended cross section of Tunnel

Considering the short length of required tunnels in this corridor, Single bored double track option is recommended for this project based on geotechnical investigations at this DPR stage. This helps to maintain the track centers as 4.5m itself. NATM is the choice for construction of tunnels normally because of the short length stretches of the tunnels (except at Kozhikkode).

However, this option shall be verified based on aerodynamics study (if required), ventilation, safety and other construction restraints along with detailed geotechnical/geological investigations depending on the length of the tunnels required to be provided. Station structures and small stretches of tunnels are recommended to be excavated by cut and cover method. These methods will be verified in detailed design stage, wherein more detailed geotechnical investigations along with surface settlement and building responses studies will be available. Long tunnels, which are unlikely for this project are constructed by bored tunneling method using Tunnel Boring Machines (TBM's). The choice of earth pressure balancing machines and/or slurry shield machines can be decided during detailing of the tunnel construction if these are required to be deployed. Tunneling process shall be scrutinized in terms of surface settlement, building monitoring etc. during DDC stage.

Based on the results of discussion from the viewpoint of cost, construction period and safety, study team recommend a double track cross-section tunnel to be constructed by the NATM method as the mountain tunnel. Ballast less track is proposed in Tunnels. Walkway with headroom of 2.5m is available for a width of 980mm on either side of proposed cross section of tunnel. The cut and cover tunnels which are situated before and after the tunnels are also proposed with ballast less track. See the **Figure below.** The possibility of single track tunnels also may be explored specially for urban tunnel required to be built in Kozhikode area in view of existence of ROBs with pile foundations for minimal disturbance / modification to the ROB structures. The decision to be taken during execution.

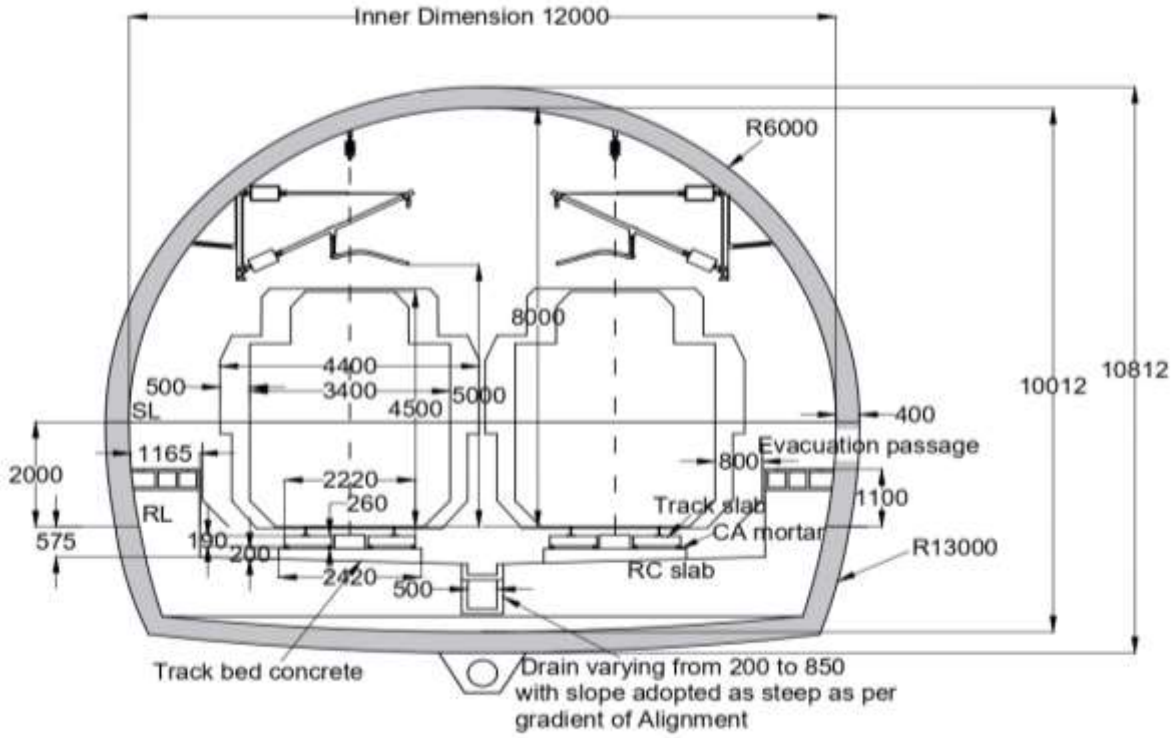



**Figure 8-104: Typical Cross section of Tunnel/ Cut & Cover before and after tunnel**

## 8.15 VIADUCT SECTIONS:

### 8.15.1 General:-

Viaduct options have been considered for stretches in the alignment like habitation area, low lying areas near water streams and rivers, viable paddy fields and when the embankment layout reaches a height of 8m and more.

A study with respect to the land cost has been conducted to choose the structure when the rail level is equal to or more than 8m from ground level and found that viaduct will be cheaper than going for embankment structure as shown in the **Figure below**;

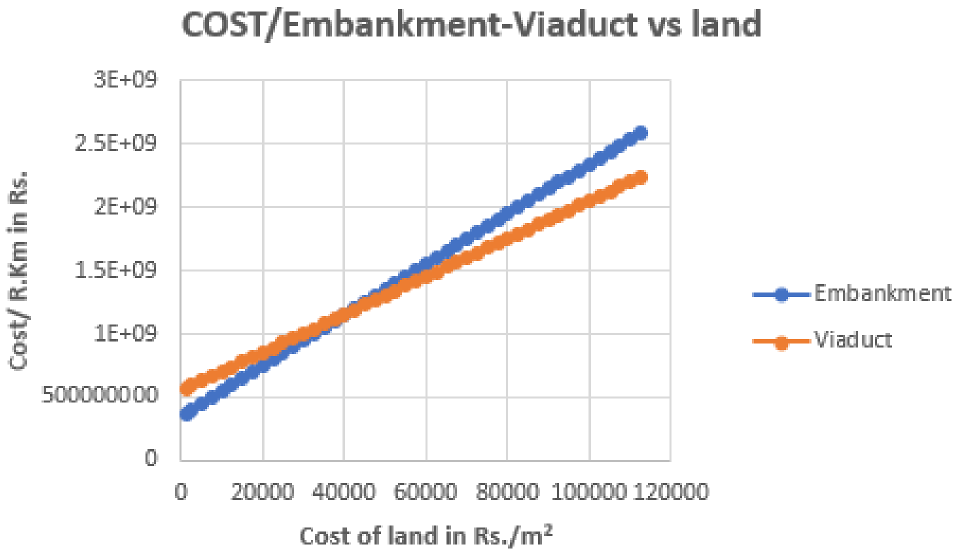



**Figure 8-105: Graph showing the land value /m$^2$, Cost Viaduct/ Embankment**

When the land cost is more than 40000/m$^2$ or 16 lakhs per cent, it is economic to select viaduct as the track supporting option. The permanent acquisition of land is restricted to 15m wide for viaduct in the proposals.

### 8.15.2 Viaduct section and its design considerations:-

Typical cross section of the deck slab must be finalized considering several aspects such as track centers, clearances to the train during operation and the demands from other disciplines regarding catenary mast and cable trough etc.

It is always economical to adopt standardized modularized structures for major project like SilverLine. The reduction in construction time and reduction in shutter cost is the cause for the reduction of cost. Hence the major portion of super structure for river bridges and viaducts are made standardized and modularized by adopting 4 nos of I Girders connected with 5nos of diaphragms including end diaphragms, for double track profile.General span of 30m has been considered.(The span 30m is found optimal vide the studies conducted in this and similar projects). The erection methodology can also be standardized. By adopting the precast structures, better quality can be ensured. The superstructure for the proposed viaduct of a standardized span of 30m center to center for SilverLine project is shown in **Figure below** - with 4 numbers of I girders, 2 columns and 6nos of piles of 1m diameter, suitable at locations where the N value is above 50 at a depth range of 25 to 30m generally, depending up on the actual calculation of pile capacity. Mix considered to be adopted is M60.

### 8.15.3 Optimal spans & optional spans to be provided for Viaducts:-

- As discussed above the optimum span of viaducts for SilverLine project is 30m as single span structures. with reference to the study conducted on account of economic considerations. The type of superstructure suitable for precast construction id I girder

and deck. The maximum span suitable for I girder is also 30m, beyond which box girders or segmental or other construction will be needed. This however is required to be reviewed during execution by DDC when more details of soil investigations will be available. While dividing the total length into spans, there will be some spans which are less or more than 30m which will be as per the site conditions.

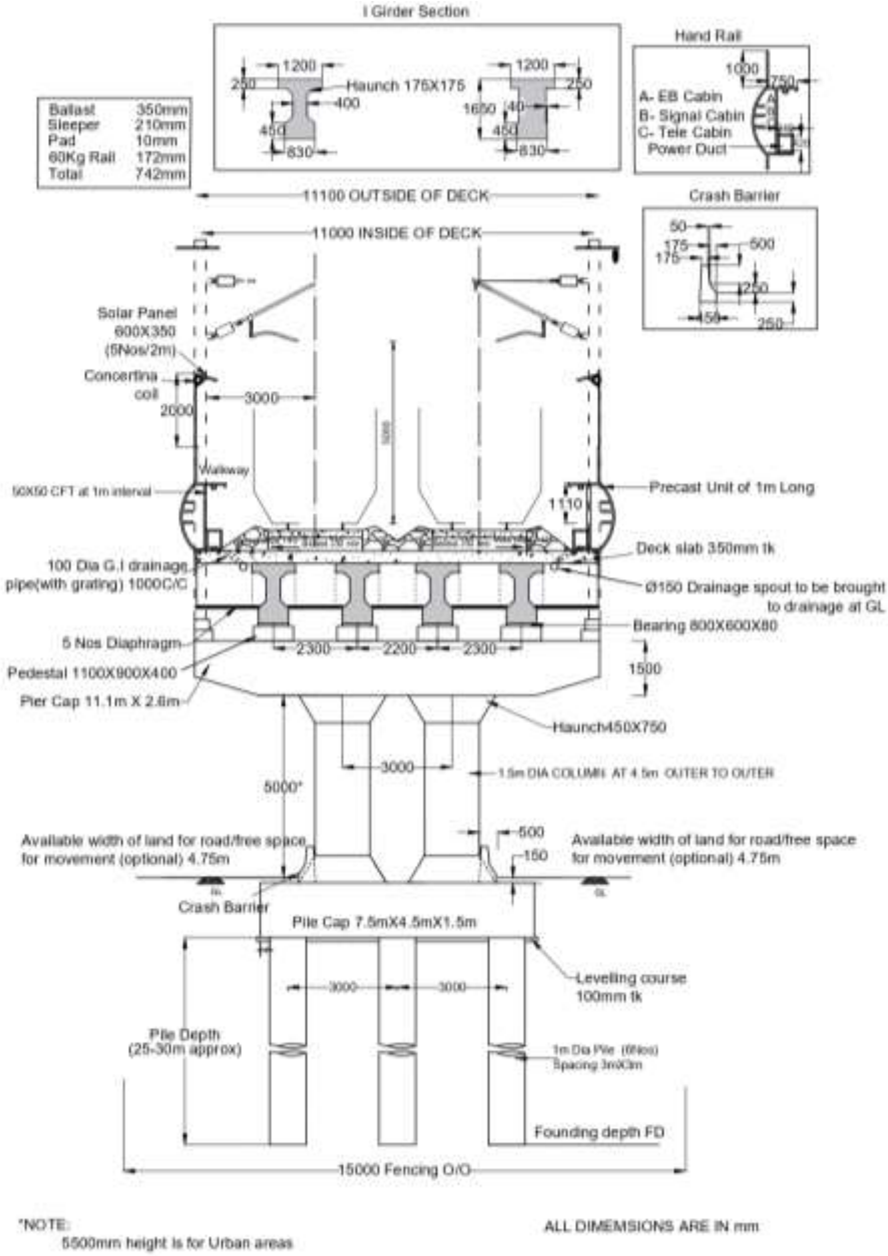



**Figure 8-106: General Arrangement of Viaduct with 4 - I girders, 2 – columns / piers, 6 piles of 1.0m diameter for less capacity piles**

➢ At locations where the hard rock is found available at a depth in range of 25 to 30m or if the soil load carrying capacity of pile of 1.2m dia is more than 650t, and the structural capacity to meet the flexural effects is adequate then the number of piles can be reduced to 4 numbers by increasing the diameter of piles to 1.2m, as shown in the **Figure below**. This type of substructure for viaducts will be economical and less

time consuming, comparing to the pile foundation with 6 numbers of piles with 1m diameter.

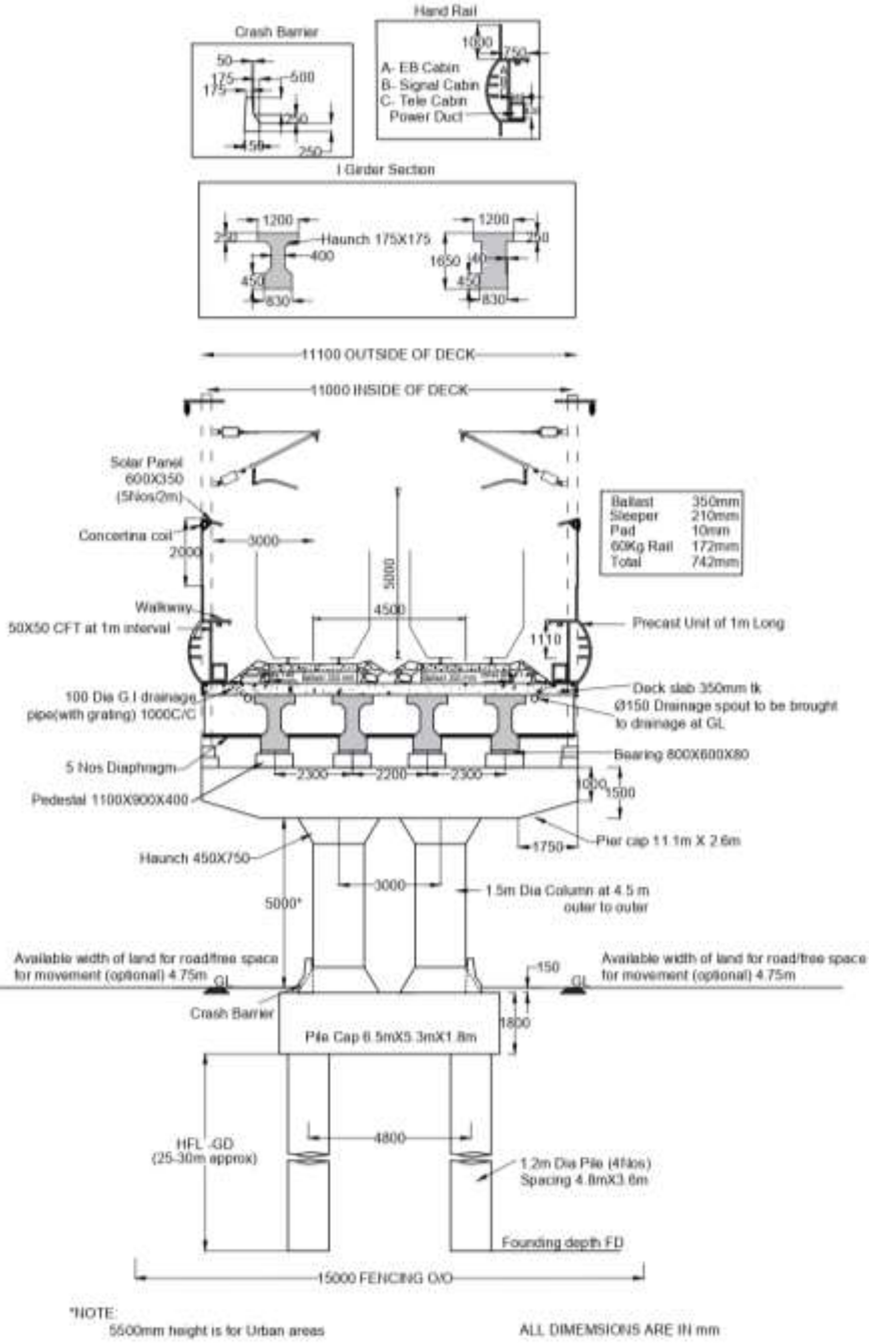



**Figure 8-107: General Arrangement of Viaduct with I girder and 4 nos of piles -1.2m dia.**

- At locations where the N value is more than 50 within a depth range between 2m to 7.5m and if there is no adjacent strucure which will be affected during excavation for foundation, open foundations for the standardized superstructure of viaduct can be adopted as shown in the **Figure below** It is to be assured that the actual pressure on soil should be less than the SBC of soil at founding depth.

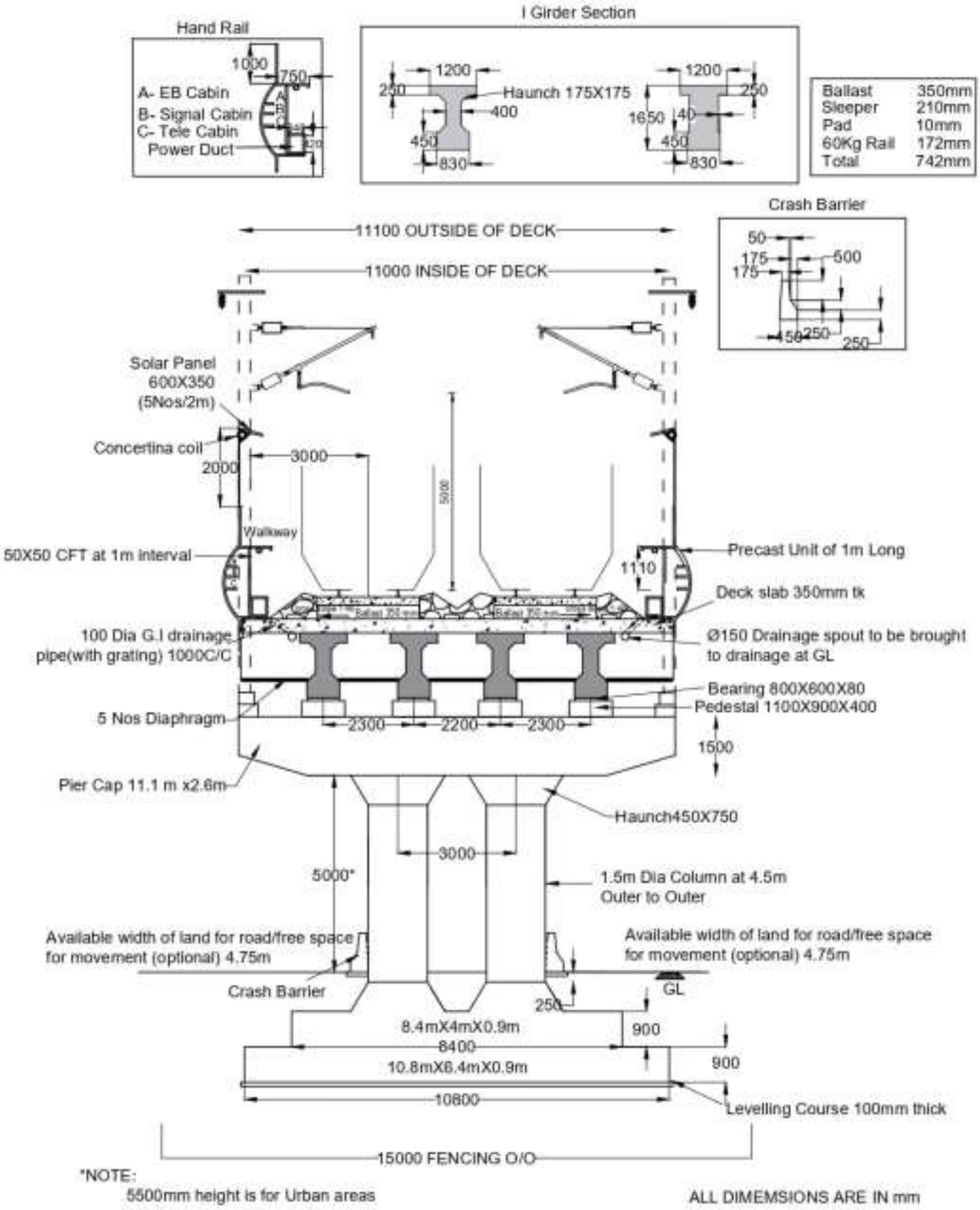



**Figure 8-108: General Arrangement of Viaduct with 4 - I girders, 2 columns / piers and open raft foundation for high SBC at top levels**

- The locations where the alignment is along the urban areas, there is a necessity to allow roads below the viaduct. This design situation can be managed by providing single columns for the substructure as shown in the **Figure below.** However, the pier columns should be safe enough to withstand the earthquake forces of zone (III), vide IS 875 part IV. The type of foundation is optional as per the geotechnical conditions as explained in the previous paragraphs. Pier with single column can be provided only at unavoidable locations.

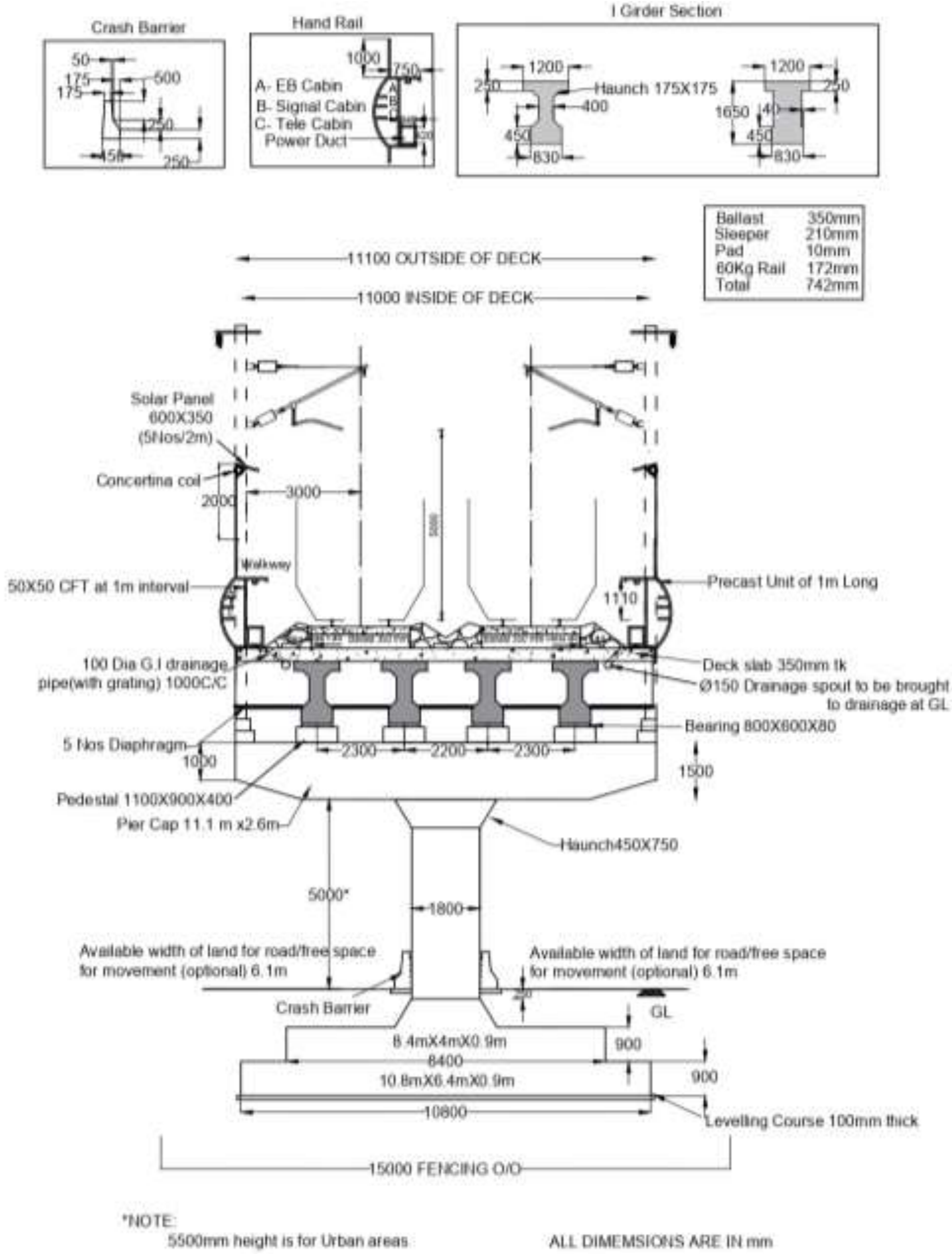



**Figure 8-109: General Arrangement of Viaduct with 4-I girders, single column pier and open foundation for permitting roads**

- At locations where the requirement of restricted depth of sub structure arises, the superstructure can be designed with twin-type-U girder as shown in the **Figure below**. This superstructure can be made as in-situ only since the width and total weight of structure are comparatively more. It is possible to make the substructure with single column of diameter ranging between 1.8m to 2m, if found adequate structurally in earthquake zone III, in urban areas. Considering the vulnerability of single column structure under earthquake forces, double columns are preferred to. Different type of foundations can also be provided with, as explained in the previous paragraphs, suitable to the soil capacity

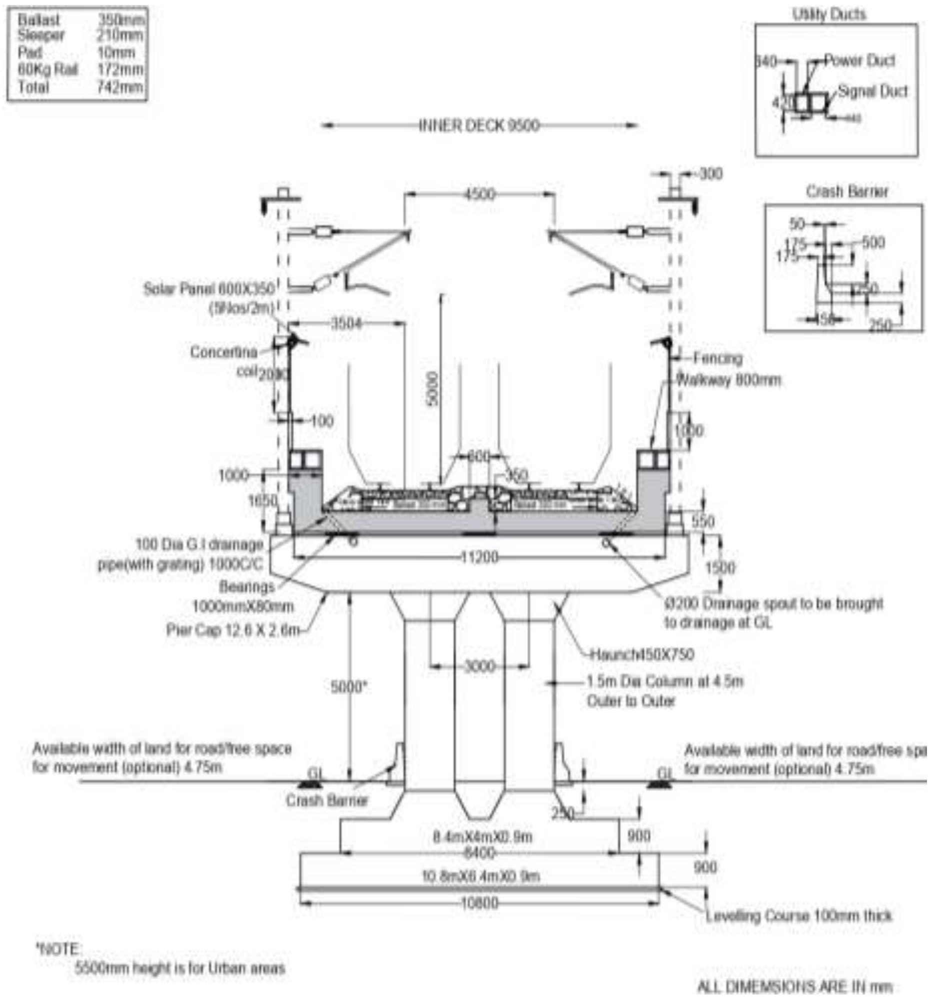



**Figure 8-110: General Arrangement of Viaduct with twin-U type girder, 2 columns and open foundations for more vertical clearance**

### *8.15.4* Miscellaneus Features on Viaducts:-

1. The location of OHE mast is considered over the pier cap at 30m center to center as shown in the Figures 8-106 to 8-110. This is advantageous as the traction in the ballast are not affected much by the vibrations on girder level as the towers are supported on pier caps. However, if traction design requires different spans in OHE, then the general arrangement shown in the **Figure below** where towers are supported over girders can be adopted suitably. The gap between OHE mast and 100 thick RCC wall on top of the cover slab of duct is kept as 500mm which is more than the required width of a foldable wheelchair, (457.2mm).

2. Other features on Viaducts include side barricades on the walkway, cable ducts or cable tray arrangements, handrail features etc. as shown in Figure below.

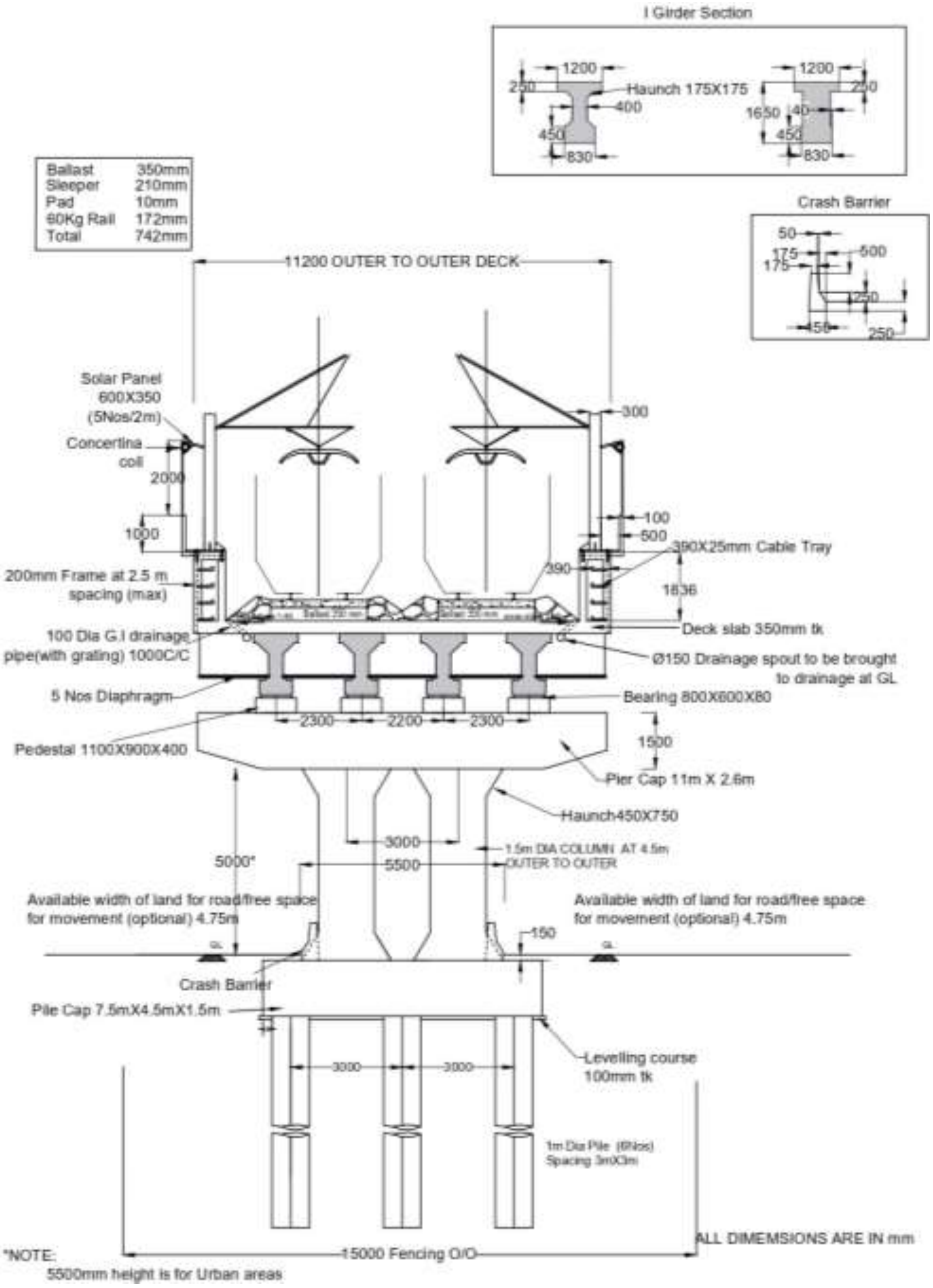



**Figure 8-111: General Arrangement of Viaduct where OHE mast is on Girder**

### 8.15.5 Discussion on the choice of type of superstructures based on construction:

Different types of constructions are possible;

- Precast Concrete Construction
- Cast-in situ Concrete construction
- Hybrid Concrete construction (HCC)

Among these three types of constructions, study team chose HCC type for superstructure of viaducts. There are 4 no.s of post-tensioned precast I girders made with high performance concrete, integrated with 5 nos of cast- in situ diaphragms and deck slab. The time requirement for precast construction is considerably lesser than in- situ construction. Use of Pre-stressed Concrete elements more in the design will help the HCC method and ultimately result in cost reduction. The accelerated bridge construction (ABC) can be achieved by adopting maximum precast sections. Moreover, by adopting standardized and modular sections for superstructure and even for substructure (only pier cap), the ABC can be improved. Figures above are showing these features clearly.

### 8.15.6 List of Viaduct locations:-

Locations/ chainages of viaduct sections proposed on elevated corridor is given in **Table 8-28** below**.**

**Table 8-28: List of Locations where Viaducts are Proposed**

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 1 | '-1.1 | 0.77 | 1.87 | 62x30m center to center (c/c) PSC I girders for 12m width up to 0.52 Km and for 69m width beyond,supported on Portal frame-piers. | **Station Building, Main and RORO yard.** |
| 2 | 0.862 | 1.612 | 0.75 | 25x30m (c/c) PSC I girders + deck | |
| 3 | 17.85 | 18.81 | 0.96 | 32x30m (c/c) PSC I girders +deck | Including paddy fields. |
| 4 | 20.1 | 20.49 | 0.39 | 13x30m—do-- | |
| 5 | 28.76 | 29.09 | 0.33 | 11x30m—do-- | Including paddy fields. |
| 6 | 33.23 | 33.44 | 0.21 | 7x30m—do-- | |
| 7 | 35.475 | 35.625 | 0.15 | 5x30m—do- | |
| 8 | 36.55 | 36.73 | 0.18 | 6x30m—do-- | |
| 9 | 38.45 | 39.26 | 0.81 | 27x30m—do-- | |

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 10 | 39.97 | 40.12 | 0.15 | 5x30m—do-- | |
| 11 | 40.5 | 40.59 | 0.09 | 3x30m—do-- | |
| 12 | 41.2 | 41.59 | 0.39 | 13x30m—do-- | Including paddy fields. |
| 13 | 42.1 | 42.31 | 0.21 | 7x30m—do-- | |
| 14 | 42.473 | 42.713 | 0.24 | 8x30m—do-- | Including paddy fields. |
| 15 | 43.48 | 43.69 | 0.21 | 7x30m—do-- | |
| 16 | 45.24 | 45.66 | 0.42 | 14x30m—do-- | |
| 17 | 46.91 | 47.15 | 0.24 | 8x30m-do-- | |
| 18 | 48.852 | 49.782 | 0.93 | 31x30m—do- | |
| 19 | 50.28 | 50.55 | 0.27 | 9x30m-do-- | |
| 20 | 51.34 | 52.24 | 0.9 | 30x30m-do-- | |
| 21 | 52.9 | 54.4 | 1.5 | 50x30m—do-- | Including paddy fields. |
| 22 | 63.76 | 64.48 | 0.72 | 24x30m-do-- | |
| 23 | 65.65 | 66.4 | 0.75 | 25x30m—do-- | |
| 24 | 66.8 | 67.94 | 1.14 | 38x30m—do-- | |
| 25 | 68.051 | 68.231 | 0.18 | 6x30m-do-- | |
| 26 | 70.52 | 70.79 | 0.27 | 9x30m—do-- | |
| 27 | 72.05 | 72.2 | 0.15 | 5x30m—do-- | |
| 28 | 72.66 | 72.93 | 0.27 | 9X30m—do-- | Pond |
| 29 | 78.36 | 78.6 | 0.24 | 8x30m—do-- | |

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 30 | 80.25 | 80.43 | 0.18 | 6x30m-do-- | |
| 31 | 80.75 | 80.96 | 0.21 | 7x30m—do-- | |
| 32 | 91.206 | 93.756 | 2.550 | 85x30m—do-- | |
| 33 | 93.794 | 94.000 | 0.206 | 7x30m—do-- | |
| 34 | 94.092 | 94.572 | 0.48 | 16x30m—do-- | |
| 35 | 99.236 | 99.386 | 0.15 | 5x30m—do-- | |
| 36 | 100.000 | 100.240 | 0.240 | 8x30m—do-- | |
| 37 | 116.460 | 116.7 | 0.24 | 8x30m—do-- | Including paddy fields. |
| 38 | 117.60 | 118.17 | 0.57 | 19x30m—do-- | Including paddy fields. |
| 39 | 119.760 | 120.060 | 0.3 | 10x30m—do-- | |
| 40 | 120.550 | 120.67 | 0.12 | 4x30m—do-- | |
| 41 | 121.050 | 121.440 | 0.39 | 13x30m—do-- | |
| 42 | 122.050 | 122.77 | 0.72 | 24x30m—do-- | |
| 43 | 123.450 | 124.020 | 0.57 | 19x30m—do-- | |
| 44 | 124.550 | 125.030 | 0.48 | 16x30m—do-- | |
| 45 | 126.150 | 126.360 | 0.210 | 7x30m—do-- | |
| 46 | 140.870 | 141.380 | 0.510 | 17x30m—do-- | Including paddy fields. |
| 47 | 142.050 | 144.000 | 1.950 | 65x30m—do-- | |
| 48 | 145.650 | 145.860 | 0.210 | 7x30m—do-- | |

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 49 | 146.300 | 147.650 | 1.350 | 45x30m—do-- | Including paddy fields. |
| 50 | 149.400 | 149.550 | 0.150 | 5x30m—do-- | |
| 51 | 151.750 | 151.870 | 0.120 | 4x30m—do-- | |
| 52 | 152.050 | 152.410 | 0.360 | 12x30m—do-- | |
| 53 | 154.000 | 154.240 | 0.240 | 8x30m—do-- | |
| 54 | 154.350 | 154.680 | 0.330 | 11x30m—do-- | |
| 55 | 157.450 | 157.750 | 0.300 | 10x30m—do-- | |
| 56 | 162.940 | 163.330 | 0.390 | 13x30m—do-- | |
| 57 | 164.600 | 165.260 | 0.660 | 22x30m—do-- | |
| 58 | 165.750 | 166.110 | 0.360 | 12x30m—do-- | |
| 59 | 167.200 | 168.820 | 1.620 | 54x30m—do-- | Including paddy fields. |
| 60 | 170.250 | 170.550 | 0.300 | 10x30m—do-- | Including paddy fields. |
| 61 | 174.600 | 175.560 | 0.960 | 32x30m—do-- | |
| 62 | 180.400 | 180.610 | 0.210 | 7x30m—do-- | |
| 63 | 189.495 | 190.485 | 0.990 | 33x30m—do-- | Including paddy fields. |
| 64 | 190.637 | 190.735 | 0.098 | 3x30m—do-- | |
| 65 | 190.887 | 191.190 | 0.303 | 10x30m—do-- | |
| 66 | 191.404 | 192.100 | 0.696 | 23x30m—do-- | |
| 67 | 192.252 | 192.800 | 0.548 | 19x30m—do-- | |

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 68 | 192.861 | 193.400 | 0.539 | 18x30m—do-- | |
| 69 | 193.644 | 194.400 | 0.756 | 25x30m—do-- | |
| 70 | 194.522 | 194.780 | 0.258 | 9x30m—do-- | |
| 71 | 194.841 | 195.801 | 0.960 | 16x30m—PSC I girder | **Ernakulam Station** |
| 72 | 196.350 | 196.680 | 0.330 | 11x30m—do-- | Including paddy fields. |
| 73 | 200.380 | 200.770 | 0.390 | 13x30m—do-- | |
| 74 | 201.850 | 202.240 | 0.390 | 13x30m—do-- | Including paddy fields |
| 75 | 203.750 | 203.990 | 0.240 | 8x30m—do-- | |
| 76 | 204.400 | 205.060 | 0.660 | 22x30m—do-- | |
| 77 | 206.790 | 208.200 | 1.410 | 47x30m—do-- | Including paddy fields |
| 78 | 208.536 | 210.126 | 1.590 | 53x30m—do-- | |
| 79 | 213.600 | 214.800 | 1.200 | 40x30m—do-- | Including paddy fields |
| 80 | 216.050 | 217.220 | 1.170 | 39x30m—do-- | Including paddy fields |
| 81 | 217.850 | 218.810 | 0.960 | 32x30m—do-- | Including paddy fields |
| 82 | 220.700 | 220.850 | 0.150 | 5x30m—do-- | |
| 83 | 221.075 | 222.305 | 1.230 | 41x30m—do-- | |
| 84 | 224.100 | 229.140 | 5.040 | 168x30m—do-- | |
| 85 | 230.950 | 231.070 | 0.120 | 4x30m—do-- | |

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 86 | 235.650 | 236.790 | 1.140 | 38x30m—do-- | Including paddy fields |
| 87 | 245.000 | 245.600 | 0.600 | 20x30m—do-- | Including paddy fields |
| 88 | 245.661 | 246.232 | 0.571 | 19.03x30m—do-- | |
| 89 | 246.299 | 249.989 | 3.690 | 123x30m—do-- | Including paddy fields |
| 90 | 250.460 | 250.910 | 0.450 | 15x30m—do-- | Including paddy fields |
| 91 | 252.500 | 252.800 | 0.300 | 10x30m—do-- | Including paddy fields |
| 92 | 255.400 | 257.110 | 1.710 | 57x30m—do-- | Including paddy fields |
| 93 | 257.210 | 263.570 | 6.360 | 212x30m—do-- | Thrissur Station |
| 94 | 263.600 | 264.050 | 0.450 | 15x30m—do-- | Including paddy fields |
| 95 | 265.040 | 266.000 | 0.960 | 32x30m—do-- | Including paddy fields |
| 96 | 272.450 | 272.900 | 0.450 | 15x30m—do-- | Including paddy fields |
| 97 | 274.470 | 274.650 | 0.180 | 6x30m—do-- | |
| 98 | 275.270 | 275.600 | 0.330 | 11x30m—do-- | |
| 99 | 276.400 | 276.700 | 0.300 | 10x30m—do-- | |
| 100 | 285.200 | 285.710 | 0.510 | 17x30m—do-- | Including paddy fields |
| 101 | 288.350 | 288.890 | 0.540 | 18x30m—do-- | |
| 102 | 294.153 | 294.573 | 0.420 | 14x30m—do-- | |

| Sl.No | Chainage from (Km) | Chainage To (Km) | Length of Viaduct (Km) | Type of Superstructure | Remarks |
|---|---|---|---|---|---|
| 103 | 301.250 | 302.240 | 0.990 | 33x30m—do-- | |
| 104 | 308.000 | 309.140 | 1.140 | 38x30m—do-- | Including paddy fields |
| 105 | 368.790 | 370.620 | 1.830 | 61x30m—do-- | |
| 106 | 370.820 | 372.200 | 1.380 | 46x30m—do-- | |
| 107 | 403.585 | 404.972 | 1.387 | 7x30m—do-- | |
| 108 | 406.000 | 407.320 | 1.320 | 44x30m—do-- | |
| 109 | 420.220 | 422.620 | 2.400 | 80x30m—do-- | |
| 110 | 424.719 | 426.249 | 1.530 | 51x30m—do-- | |
| 111 | 437.022 | 437.322 | 0.300 | 10x30m—do-- | |
| 112 | 438.083 | 438.263 | 0.180 | 6x30m—do-- | |
| 113 | 440.015 | 442.835 | 2.820 | 94x30m—do-- | |
| 114 | 445.310 | 445.670 | 0.360 | 12x30m—do-- | |
| 115 | 518.535 | 519.015 | 0.480 | 16x30m—do-- | |
| 116 | 524.585 | 525.035 | 0.450 | 15x30m—do-- | |

## 8.16 BRIDGES:

Bridges and bridge approaches are the critical locations in view of the nature of area, poor soil condition etc. where a thorough analysis for structural capacity is required for running high speed services. This is the area to be concentrated in the initial stage itself since the time of construction will be more, it is required to complete for making connectivity between places on either side of rivers in the alignment for smooth progress of the project.

### 8.16.1 Important Bridges:-

Among the 55 locations of river bridges in the project, around 9 bridges are identified as important bridges. These bridges are at chainages Km 208.200 - Periyar River, Km 307.732 - Bharathapuzha River, Km 342.127 - Kadalundi river, Km 370.624 -Korapuzha river, Km 454.100 - Valapattanam river, Km 467.900 - Kuppam river, Km 475.200 - Perumba river, Km 480.368 and Km 529.900 - Chandragiri puzha river.

Important bridges are defined in IR parlance as those having a linear waterway of 300m or a total waterway of 1000 sqm or more. Same others are also classified as important depending on considerations such as depth of waterway, extent of river training works and maintenance problems.

For deciding the span of any river bridge, irrespective of standardized spans, another two criteria's we have considered are the distance from the existing bridge, if any, for keeping undisturbed flow of water, and the proximity to the estuary/ocean since the flow pattern cannot be defined.

The periyar river bridge location is around 3km away from existing railway bridge. The Bharathapuzha river bridge location is also far away from the existing railway bridge location. At Kadalundi river bridge location the spacing between existing railway bridge and proposed SilverLine bridge is 50m(average), and hence it is proposed to provide the same span arrangements as provided by Southern Railway. The existing bridge was provided with 33x18.3+1x9.1m spans. At the Feroke river bridge location, the distance from existing rail bridge is 15 to 20m. The existing bridge has 7 x 30.5m spans. The linear waterway of this bridge is calculated as 7x30.5m + 6x2.1 (pier width) = 226.1m. The water depth is varying from 16-17m (as obtained from Southern Railway records. Hence, the total water way is calculated as 226.1x16.5= 3730.65 sqm > 1000 sqm (and classified as important bridge as per definition). The Korapuzha river bridge location is far by around 140m from the existing railway bridge. Hence it is decided not to provide the same span provided by Southern Railway. At the location of Valapattanam river, the distance from existing bridge is 15m. The spans provided for existing railway bridge is 12x 30.5m. The general water depth is around 7m as per the information from Southern Railway. The Kappam river bridge location is far away. The Perumba River bridge location is very near say 20m. Hence the proposed bridge span should also be of same as given for existing railway bridge. The river bridge at ch. 480.368 is very far from the existing bridge. The bridge location in Chandragiripuzha river is at a closer distance of 45m from the existing railway bridge. Hence the same spans are proposed here also. The existing bridge was provided with 12x 30.5m span. The depth of water may be around 4 to 5m. Alignment over all these bridges are straight and square.

All these bridges will be provided with pile foundations of diameter 1.2m/6nos minimum (as considered for estimate purpose). Through detailed structural and hydraulic designs, the

number and actual founding depth of pile foundations can be decided for each bridge. Rock availability at Feroke location is at 34 to 59 m as per geo-tech investigation done at nearby bore hole at GT 84.

LWR/CWR forces from Bridge Rules of IR were considered in the design assuming the cutting of rail during destressing operation or for any such repair.

All bridge designs will be through a specialized design agency to be done before execution.

### 8.16.2 Foundation Options:-

The design and decision on the types of foundation and its depth etc. is to be done on the basis of the characteristics of the soil obtaining at each location. Most prevalent soils are alluvium soil, saline and laterite type along the alignment. A brief about their location is described below;

- **Alluvium**
  - Coastal Alluvium along the coastal tracts for approx. 10 km in width
  - Riverine alluvium along the banks of rivers and tributaries
  - Onattukara Alluvium which are marine deposits
- **Laterite**
  - Predominant in northern parts of the State and are suitable for Embankment and load bearing structures.
- **Red Loam**
  - Deposit along foothills.
- **Hydromorphic**
  - Brown hydromorphic.
  - Saline Hydromorphic.

For all perennial rivers, the desired foundation is pile type. Other than Feroke river, all other rivers are on average water depth of 7m and below. The bridge across Feroke river (estuary) require very deep foundation since the water depth is around 18m as per the underwater inspection report of Southern Railway. A lining depth of 9m has been considered generally in the estimate for underwater concreting.

Open foundation can be provided for bridges across rivers other than perennial type and wherever the depth of hard soil strata/ rock bed is available within 6m from the riverbed or 7.5m from GL as per detailed design .

There will be two numbers of pier columns of 1.5m diameter. Six numbers of 1.2m diameter piles are proposed per pier. Pile cap will be cast above LWL ( Low Water Level).

### 8.16.3 Economical span:-

The economical span for river bridges is also considered as 30m, same as that of viaducts considered for estimate purpose. This can be reviewed during execution stage depending upon the type of design adopted on the basis of detailed investigations available. Provision of Barge during construction up to the stage of pier cap has been considered in the estimate.

### 8.16.4 Standard spans for superstructure:-

The design of bridge openings is required to be done as per hydrological study to be done before execution unavoidably at the locations where there is no existing bridge located nearby the alignment. However at this stage, the bridges proposed parallel to the existing Railway bridges and within 50m from the existing railway bridges, are proposed with standard spans of RDSO (dimensioned to keep the double track and the track centers at 4.5m center to center) for superstructure so as to match with the span of existing bridge. All other spans are standardized with PSC-I girders of 30m length as used for viaducts. Inspection platforms are to be provided on every pier.

Box culverts of suitable dimension can be provided for all waterways less than 12m span (For minor bridges) and preferably where the water body is not perennial. If there are multiple spans of 6.1m for a river bridge, total span of 12.2m and higher can be adopted wherever there is existing bridge span parallel and within a short distance of 50m from the existing railway bridge. This is required to be reviewed at the time of execution. **Figure below** shows typical Box culvert of 8m span.

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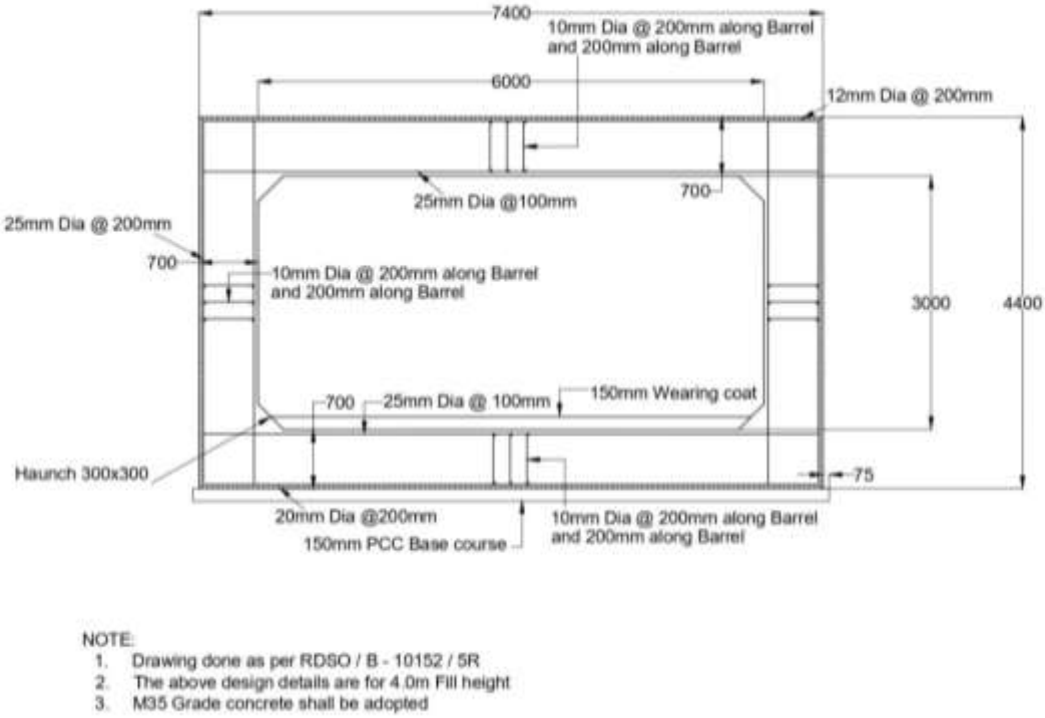


**Figure 8-112: Typical Box culvert for a span of 8m**

### 8.16.5 Recommended Cross Sections Of River Bridge Structure:-

Two types of bridge superstructures are recommended generally. One is made with precast post tensioned I girders integrated with Diaphragms and top slab and the other is made with in-situ restricted depth type PSC U girder. The restricted depth type is recommended only for the navigation span, generally at the midspan of each bridge, if it is required at that location of alignment. Since the SilverLine alignment is not crossing any national waterways except, the vertical clearance from HFL to bottom of girder (BoG) at the navigation span is maintained as minimum of 5m, as per the guidelines from Inland waterways of Kerala. The general arrangement of River Bridges includes inspection platforms additionally when comparing with the general arrangement of viaducts. The trolley refuges are required to be provided on every pier on either side of bridge. At these locations, in order to pass the signal & power cables, ducts can be used, and the walkway arrangements need to be stopped at 1.5m from the center line of pier cap. The 3m span of walkway slab should be cast on recommendation of DDC. All these details are shown in **Figures below.**

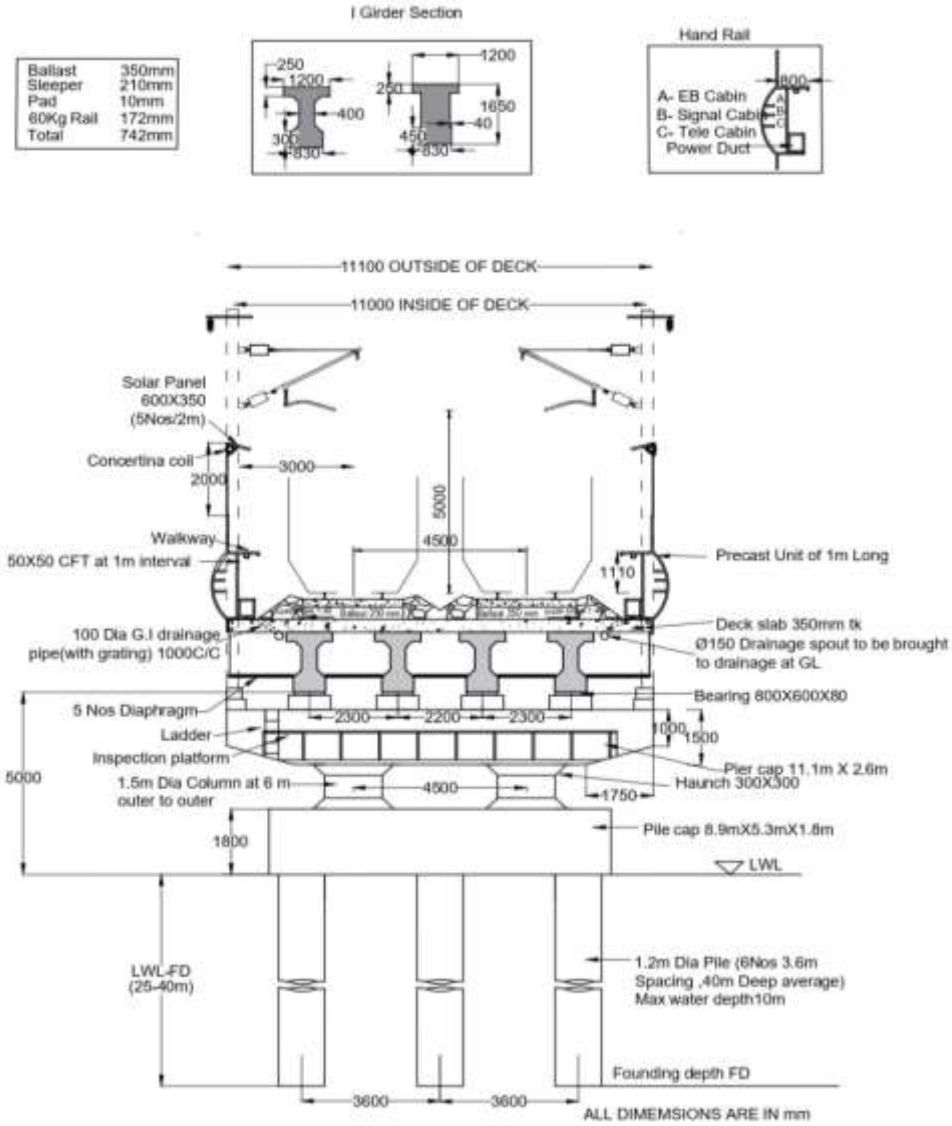


**Figure 8-113: General Arrangement of River bridge with 4 - I girders, 2 – columns and 6 piles of 1.2m diameter**

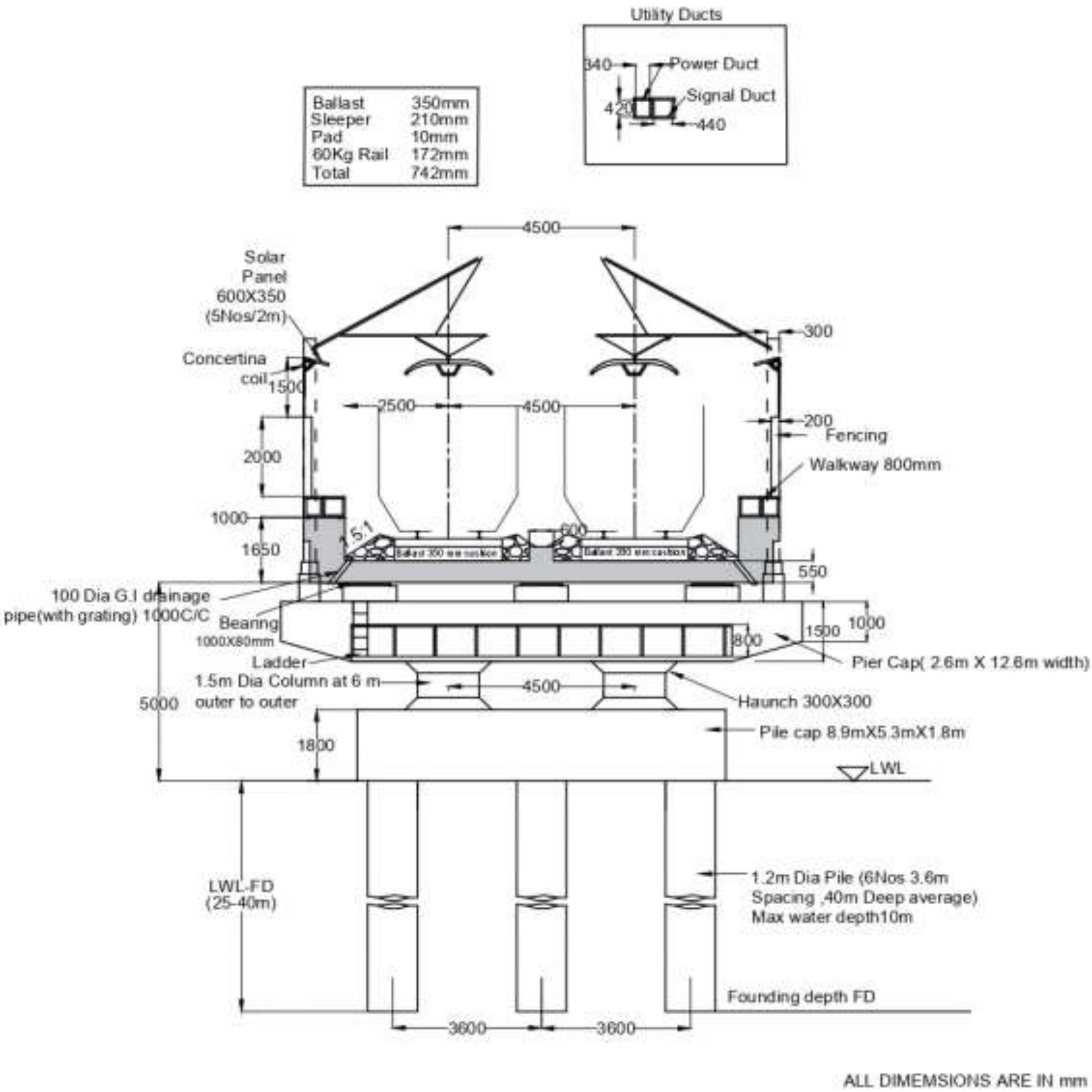


**Figure 8-114: General Arrangement of River bridge with Twin U - type girder, 2 – columns and 6 - piles of 1.2m diameter**

## 8.16.6 Decision of Superstructure Construction: Pre-cast vs Cast-in-situ

The choice of superstructure construction between Cast in situ and Precast depends upon various factors as elaborated hereunder;

### 1. Cast in situ:-

The cast-in situ type of construction has been explained in section earlier (viaduct). Necessity of the same in the case of river bridge construction is explained here.

The depth of construction will be restricted when there is proposal for navigation, below and across the bridge span. Twin U type girder having three webs upwards and accommodating two tracks at 4.5m apart, can be used when this requirement arises. This type of girders can be made as cast- in – situ only since the total width of deck will be about 11m (approximately) and weight will be high.

**2. Precast:-**

The precast type of construction has been explained in section earlier (viaduct). Necessity of the same in the case of river bridge construction is explained here.

The superstructure can be made with precast PSC-I girders generally. The integrating deck slab will alone be of cast-in-situ type. In general, the superstructure of River bridge and viaducts will be standardized with 30m I girders. Each I girder can be launched in position using arrangement having launching girder of double span length, hoist on transverse portal fitted on piers, Trolleys 2 numbers to support the PSC girders at support, winch and pulley arrangements for longitudinal slewing, small cranes for additional arrangements and local pickups, etc.

Other precast units on bridge deck are the arrangements for signal and power ducts and the walkway which may be finalized during execution.

Suitable decision on Precast or Cast in situ structure has to taken after due deliberations during execution keeping pros and cons of both and the site requirements in mind.

**3. Limits of Deflection:-**

The increased vibration due to semi high speed can be controlled by controlling the deflection of superstructure of each bridge. For this, the stiffness needs to be increased. This can be achieved by adopting concrete material having increased modulus of elasticity(E) as well as enough depth of girder so that the product of E x I (the moment of inertia), will be maximum to get the minimum deflection. The deflection for all the girders is limited to span/1500. The characteristic strength of mix is limited to M75 as per Euro Code. The E value is directly related to the characteristic strength of concrete mix adopted. Such high strength concrete can be achieved effectively in Precast construction only.

### 8.16.7 Load Combinations:-

- For ready reference, a discussion on load combination in design is given belowfor preliminary design,though the final designs will be  based on specified codes only.As per UIC code or more precisely as per BS 5400 part2, there are three load combinations to be observed for the design of all bridge structures. These combinations are same as given in the IRSCBC of RDSO. However, the

corresponding load factors are taken from BS 5400- part2 for arriving at the cross sections of each component of the bridges.

- **With Earthquake Loads:-**

Entire Kerala is situated in the seismic zone III. Hence the corresponding seismic coefficients as per Bridge rules to be applied for the design of Neoprene/ pot bearings and all the substructures. The response spectrum method may also be agreeable as per the Eurocodes.

- **With Wind loads:-**

Generally, the load combination is such that either earthquake load or wind load whichever is critical to be considered with other specified loads for the design of all bridge structures. The general intensity of wind pressure corresponding to the Kerala zone is 100 kg/m$^2$(ref: IS 875 part3 and SP 38).

### 8.16.8 List Of Waterways In The Silverline Corridor:-

There are 65 major bridges and 300 minor bridges in the SilverLine corridor. The **Table 8-29** are providing the combined list of both major and minor bridges and, corresponding locations and other details along the alignment.

**Table 8-29: List of river bridges and locations along the alignment**

| S.No. | Chainage | Span of Bridge | Type of Crossing | Name of Crossing | Length |
|---|---|---|---|---|---|
| 1 | 0+815 | 3x30.5m PSC Gr | Bridge | Parvathy puthanar | 91.5 |
| 2 | 15+165 | 3x30.5m PSC Gr | Bridge | Parvathy puthanar | 91.5 |
| 3 | 19+072 | 3x30.5m PSC Gr | River Br | Maamam River | 91.5 |
| 4 | 21+205 | 1x30.5 PSC Gr | River Br | Maamam river | 30.5 |
| 5 | 22+516 | 5x30.5 PSC Gr | River Br | Vamanapuram River | 152.5 |
| 6 | 23+072 | 3x30.5 PSC Gr | River Br | Vamanapuram River | 91.5 |
| 7 | 24+533 | 1x30.5 PSC Gr+2x18 PSC Gr | River Br | Vamanapuram River | 66.5 |
| 8 | 48+805 | 3x30.5 PSC Gr | River Br | Ithikar River | 91.5 |
| 9 | 70+600 | 7x30.5m PSC Gr | River Br | Kallada River | 213.5 |

| S.No. | Chainage | Span of Bridge | Type of Crossing | Name of Crossing | Length |
|---|---|---|---|---|---|
| 10 | 76+097 | 4x30.5 m PSC Gr | Bridge | Pond | 122 |
| 11 | 93+775 | 4x9 m PSC Gr | River Br | Major River | 38 |
| 12 | 94+045 | 3x30.5 m PSC Gr | River Br | Major River | 91.5 |
| 13 | 94+945 | 3x30.5 PSC Gr | River Br | Achankoil River | 91.5 |
| 14 | 105+691 | 4x30.5m PSC Gr | River Br | Pampa River | 122 |
| 15 | 112+345 | 3x30.5m PSC Gr | River Br | Manimala River | 91.5 |
| 16 | 115+465 | 1x30.5m PSC Gr | River Br | Minor River | 30.5 |
| 17 | 135+473 | 1x30.5 PSC Gr+2x18 PSC Gr | River Br | Kudoor River | 66.5 |
| 18 | 138+482 | 1x30.5m PSC Gr | River Br | Meenachil River | 30.5 |
| 19 | 140+161 | 4x30.5m PSC Gr | River Br | Meenachil River | 122 |
| 20 | 153+341 | 6X30.5m PSC Gr | River Br | Pond | 183 |
| 21 | 169+476 | 5x30.5m PSC Gr | River Br | River | 152.5 |
| 22 | 190+561 | 5x30.5m PSC Gr | River Br | Chithrapuzha | 152.5 |
| 23 | 190+811 | 5x30.5m PSC Gr | River Br | Chithrapuzha | 152.5 |
| 24 | 191+296 | 7x30.5m PSC Gr | River Br | Chithrapuzha | 213.5 |
| 25 | 192+176 | 5x30.5m PSC Gr | River Br | Chithrapuzha | 152.5 |
| 26 | 192+830 | 2x30.5m PSC Gr | River Br | Kadambrayar | 61 |
| 27 | 193+522 | 8x30.5m PSC Gr | River Br | Kadambrayar | 244 |
| 28 | 194+461 | 4x30.5m PSC Gr | River Br | Kadambrayar | 122 |
| 29 | 194+810 | 2x30.5m PSC Gr | River Br | Kadambrayar | 61 |
| 30 | 197+702 | 2x30.5m PSC Gr | River Br | Kadambrayar | 61 |
| 31 | 198+160 | 1x30.5m PSC Gr | River Br | Kadambrayar | 30.5 |

| S.No. | Chainage | Span of Bridge | Type of Crossing | Name of Crossing | Length |
|---|---|---|---|---|---|
| 32 | 208+368 | 11x30.5m PSC Gr Bridge | River Br | Periyar River | 335.5 |
| 33 | 222+366 | 3x30.5m PSC Gr | River Br | Periyar River | 91.5 |
| 34 | 245+630 | 2x30.5m PSC Gr | River Br | Minor River | 61 |
| 35 | 246+265 | 1x30.5 PSC Gr+2x18 PSC Gr | River Br | River | 66.5 |
| 36 | 263+585 | 1x30.5m PSC Gr | River Br | River | 30.5 |
| 37 | 307+155 | 27x30.5m PSc Gr Bridge | River Br | Bharathapuzha River | 823.5 |
| 38 | 313+785 | 3x30.5m PSC Gr | River Br | Ponnani River | 91.5 |
| 39 | 317+065 | 3x30.5m PSC Gr | River Br | Ponnani River | 91.5 |
| 40 | 329+356 | 5x30.5m PSC Gr | River Br | Poorapuzha | 152.5 |
| 41 | 342+508 | 25x30.5m PSC Gr | River Br | Kadalundi River | 762.5 |
| 42 | 346+000 | 6x30.5m PSC Gr | River Br | Chaliayar River | 183 |
| 43 | 348+467 | 8x30.5m PSC Gr | River Br | Chaliayar River | 244 |
| 44 | 370+720 | 6x30.5m PSC Gr+2x9 PSC Gr | River Br | Korapuzha River | 200 |
| 45 | 399+960 | 17x30.5m PSC Gr | River Br | Major River | 519 |
| 46 | 417+277 | 9x30.5m PSC Gr | River Br | Mayyazhi River | 274.5 |
| 47 | 427+202 | 10x30.5m PSC Gr | River Br | Kuyyali River | 305 |
| 48 | 428+263 | 15x30.5m PSC Gr | River Br | Dharmadam River | 457.5 |
| 49 | 430+283 | 15x30.5m PSC Gr | River Br | Anjarakandi River | 457.5 |
| 50 | 453+133 | 13x30.5m PSC Gr | River Br | Vallapatanam River | 396.5 |
| 51 | 466+994 | 17x30.5m PSC Gr | River Br | Kuppam River | 518.5 |
| 52 | 470+611 | 7x30.5m PSC Gr + 1 twin U type PSC Gr | River Br | Vayalapram River | 244 |

| S.No. | Chainage | Span of Bridge | Type of Crossing | Name of Crossing | Length |
|---|---|---|---|---|---|
| 53 | 474+690 | 43x30.5m PSC Gr | River Br | Perumba River | 1312 |
| 54 | 479+569 | 23x30.5m PSC Gr + 1 twin U type PSC Gr | River Br | Major River | 732 |
| 55 | 494+210 | 1x30.5+2X18m PSC Gr | River Br | Major River | 50 |
| 56 | 495+277 | 6x30.5m PSC Gr + 1 twin U type PSC Gr | River Br | Major River | 213.5 |
| 57 | 499+845 | 2x30.5m PSC Gr + 1 twin U type PSC Gr | River Br | Karingodu River | 91.5 |
| 58 | 513+110 | 2x30.5m PSC Gr + 1 twin U type PSC Gr | River Br | Chithari River | 91.5 |
| 59 | 518+341 | 7x30.5m PSC Gr | River Br | Major River | 213.5 |
| 60 | 523+780 | 3x30.5m PSC Gr | River Br | Chithari River | 91.5 |
| 61 | 526+780 | 3x30.5m PSC Gr | River Br | Chandragiri River | 91.5 |
| 62 | 527+563 | 15x30.5m PSC Gr | River Br | Major River | 467.5 |

### 8.16.9 RAIL OVER RAIL AND RAIL UNDER RAIL BRIDGES (ROR AND RUR):

There are six locations where the SilverLine has to cross the existing railway lines as mentioned on **Table 8-30.**

**Table 8-30: List of RoR and RuR locations along the alignment**

| Sl No | Chainage | ROR / RUR | Angle of crossing (deg) | Exg. Span (m) | *Type of Structures | Remarks |
|---|---|---|---|---|---|---|
| 1 | 63.015 | RUR | 35 | 26 | Cut & Cover<br>1x13.25x7.335 RC Box | Silver line is below the existing Railway at Kundara |

| Sl No | Chainage | ROR / RUR | Angle of crossing (deg) | Exg. Span (m) | *Type of Structures | Remarks |
|---|---|---|---|---|---|---|
| 2 | 190.18 | ROR | 20 | 22 | Composite Girder(Skew crossing) 1x 33.5m+ PSC girder 1x 15m | At Ambalamugal(IOC siding)(Track 33.5m + Road 15.0m) |
| 3 | 214.16 | ROR | 78 | 114 | Composite Girders | At Angamaly( considered future track also) |
| 4 | 262.9 | ROR | 75 | 94 | Composite Girders | At Thrissur( considered Double track) |
| 5 | 405.050 | ROR | 75 | 200 | Composite Girders | Existing Tracks only considered |
| 6 | 406.265 | ROR | 70 | 95 | Composite Girders | Existing Tracks only considered |
| 7 | 420.900 | ROR | 65 | 85 | Composite Girders | Existing Tracks only considered |
| 8 | 421.960 | ROR | 45 | 54 | Composite Girders | Existing Tracks only considered |
| 9 | 427.170 | ROR | 80 | 210 | Composite Girders | Existing Tracks only considered |
| 10 | 521.815 | RUR | 34 | 26 | Cut & Cover | Uduma |

The maximum desirable skew angle for RoRs to be fixed is considered as 45 degree. The locations where the track is crossing with skew angle more than 45 degree will be

arranged with special structures like Portal Frames supporting the composite girders-deck assembly or balanced cantilever bridges. Generally the superstructure of Steel-RCC composite type will be provided for RoRs. The cross section showing this general arrangement is given in the **Figures below**;

Decision on spans, type, etc. will be based on detailed designs at the time of execution.

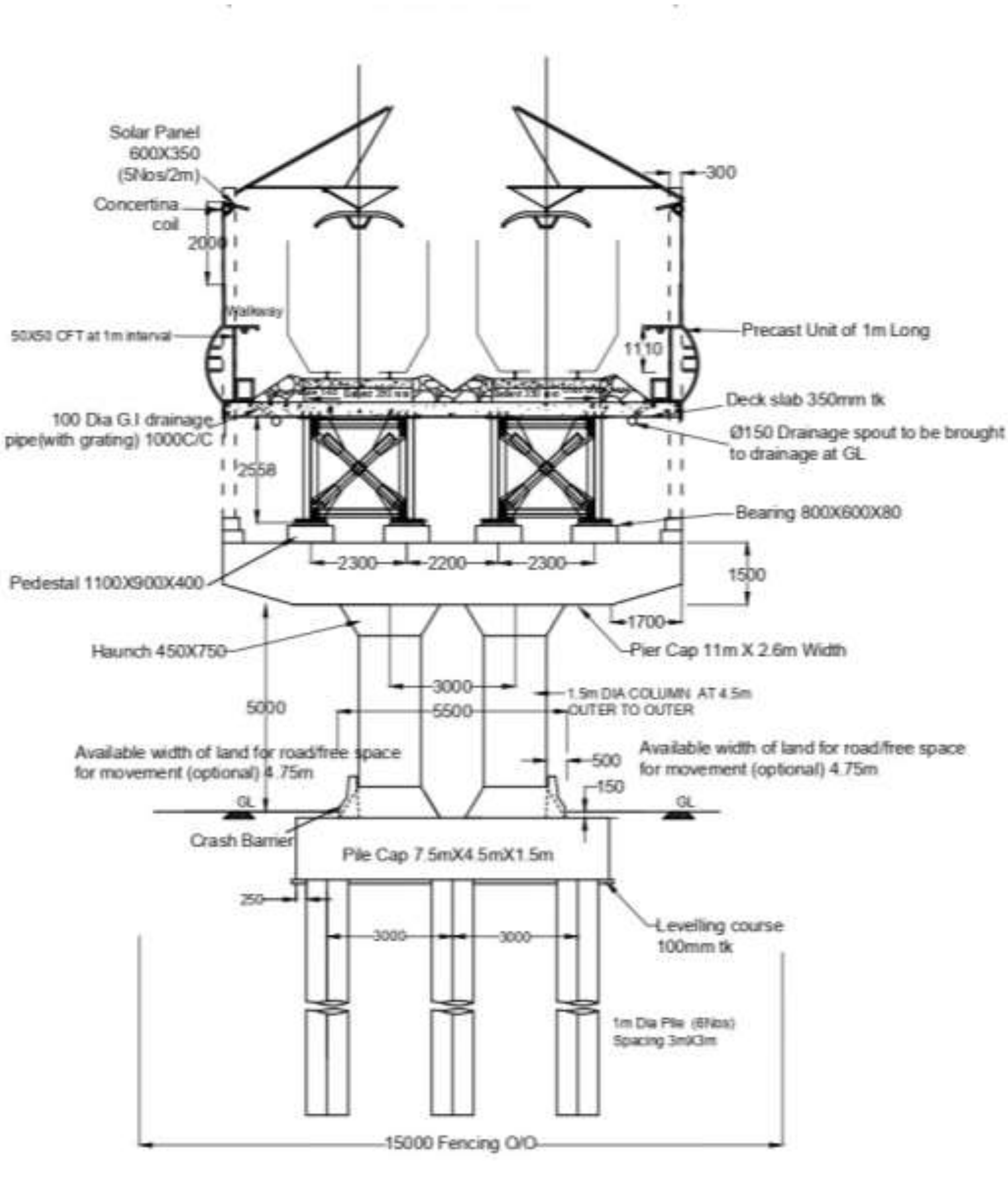


**Figure 8-115: General Arrangement of RoR with Steel - RCC Composite Girder**

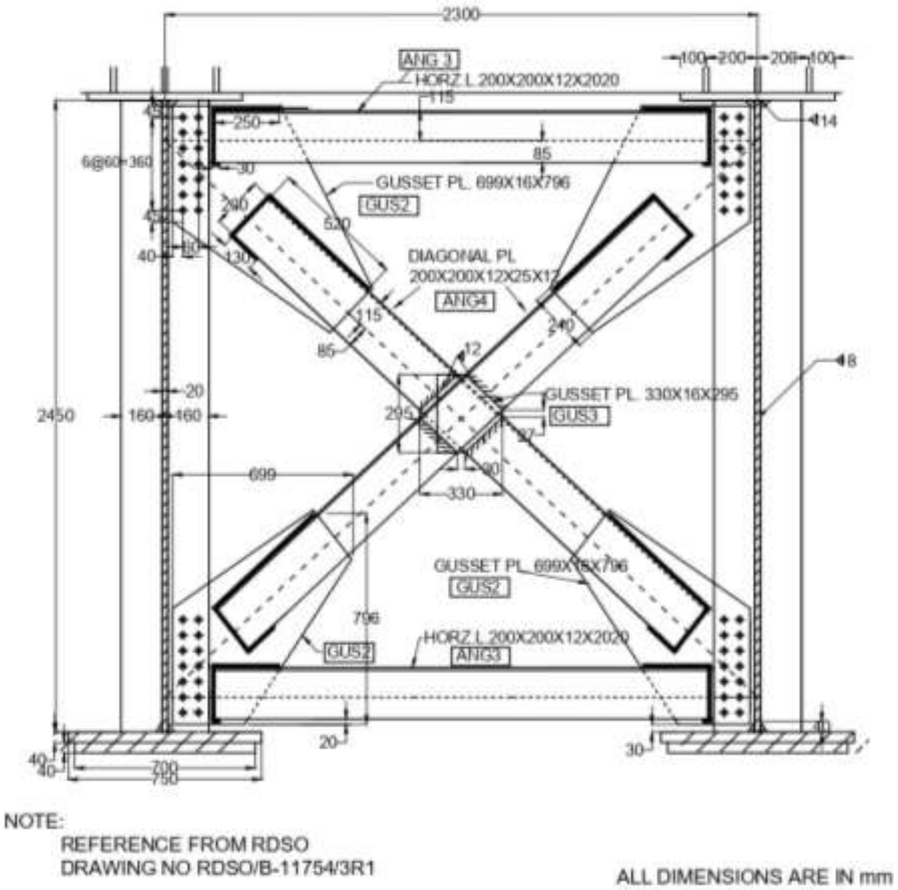


Figure 8-116: Enlarged Cross section of Composite Girder

## 8.17 ROBs (ROAD OVER BRIDGES) AND ROAD UNDER BRIDGES:

1) For NH, SH and ODRs, RoBs:-

National highways width is 45m generally in the State. The same is reduced to 31.1m while entering to the bridge proper. RCC box of inner dimensions 12 m x 7.5 m with barrel length 32m is recommended for NH crossing above SilverLine. For all existing ROBs, vertical clearance above the rail level of 5.77m is to be maintained after discussions with the Client. All new ROBs are to be planned with 6.45m. The General arrangement of the same is given in **Figure below.**

ROBs of continuous spans are normally not adopted since the difference between minimum and maximum temperature of area should not preferably exceed 17 degree. It is desirable to avoid expansion joints on the ROBs and continuous span will improve the road driving. It can be reviewed during execution.

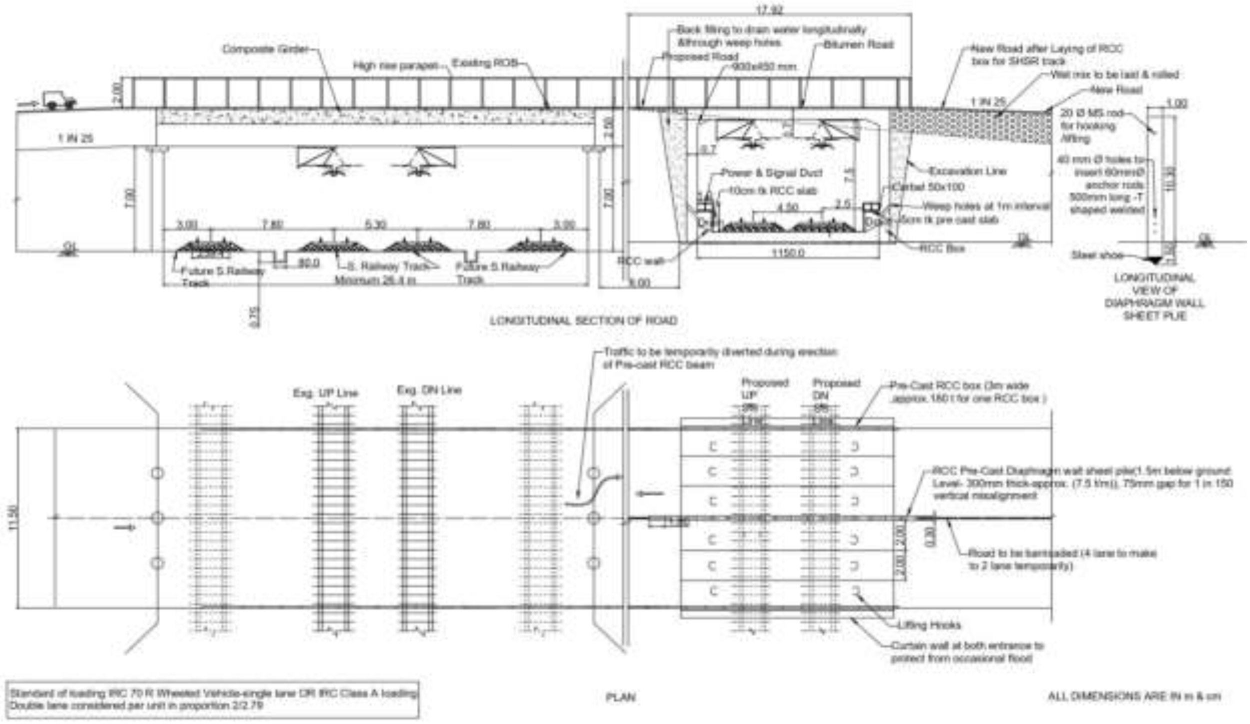


**Figure 8-117: Typical Cross section of ROB**

In the case of SHs, RCC box with same dimension can be provided with barrel length 12m which can accommodate 7.5m carriage way, 2 side foot paths, two side crash barriers and two side high rise parapets, however this is subject to acceptance by road authorities.

In the case of ODR, the same dimensioned RCC box with barrel length 10.3m to accommodate 7.5m carriage way, one side foot path, one side mounting type CB, one side CB cum high rise parapet and one High rise parapet.

RCC box of 5m x 3.6m has been recommended for the crossing of village road.

2) RUBs (Road under Bridges):-

All RUBs corresponding to NH, SH and other major district roads will be provided with PSC bridge (viaduct) of 2x 30m span or RCC boxes of dimension 11.5m x 5.5m or 10m x 5.5m respectively.

RUBs made with RCC box of dimension 4mx 2.5m has been recommended for kutcha road crossings.

Complete list of all proposed ROBs, RUBs, and subways is included in Annexure to this DPR. A sample list in first 40 km length of alignment is shown in **Table 8-31** for study..

**Table 8-31: List of Locations where Roads (ROBs/RUBs) Crossing the Alignment & Proposed Structures**

*(First 40 Km, complete list attached in annexure-1)*

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1 | 1.842 | Village Rd | F | 6.9 | 4.3 | 40 | 4.5 | 1X5.15X3.6 (RC Box) | | 31.1 | 2.57 | |
| 2 | 2.238 | Village Rd | F | 5.8 | 4.3 | 55 | 5 | 1X5.15X3.6 (RC Box) | | 43 | 1.5 | |
| 3 | 2.425 | Village Rd | F | 6.2 | 4.3 | 58 | | 1X5.15X3.6 (RC Box) | | 47 | 1.9 | |
| 4 | 4.326 | ODR | F | 2.4 | 9.39 | 0 | 8 | 12x30 PSC Gr+150x2 RE approach | 650 | | LC/11m from CL to CL of nearest track | |
| 5 | 5.050 | Kutcha Rd | F | 2.6 | 3 | 17 | | 1x4x2.5 (RC Box) | | 53 | Additional | 0.42 |
| 6 | 5.600 | Kutcha Rd | F | 2.9 | 3 | 0 | | 1x4x2.5 (RC Box) | | 50 | Additional | 0.12 |
| 7 | 6.080 | Kutcha Rd | F | 1.5 | 3 | 30 | 2 | 1x4x2.5 (RC Box) | | 26 | | 1.5 |
| 9 | 6.425 | Village Rd | F | 0.8 | 4.3 | | | 1x5.15x3.6( RC Box) | | 50 | Additional | 3.55 |
| 10 | 6.850 | Kutcha Rd | F | 0.4 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 2.6 |
| 11 | 7.207 | Modified ROB | C | 0.3 | 7.16 | 25 | 12 | Mini ROB 2x12x7.5 RC box | | 20 | VC 5.77 considered | 0.42 |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 12 | 7.750 | Kutcha Rd | F | 0.8 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 2.2 |
| 13 | 8.200 | Kutcha Rd | F | 0.7 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 2.34 |
| 14 | 8.868 | ODR | F | 1 | 9.39 | 15 | 7 | 9x30PSC Gr+150x2 RE approach | 570 | | LC | |
| 15 | 10.017 | ODR | F | 0 | 9.39 | 38 | 7 | 7x30PSC Gr+150x2 RE approach | 520 | | LC | |
| 16 | 10.580 | Kutcha Rd | F | 2.1 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 0.88 |
| 17 | 11.200 | Kutcha Rd | F | 1.5 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 1.5 |
| 18 | 11.954 | ODR | F | 3.3 | 9.39 | 20 | 4.5 | 13x30PSC gr+150x2 RE approach | 683 | | LC | |
| 19 | 13.454 | MDR | C | 0.5 | 9.39 | 27 | 6.5 | 7x30PSC gr+150x2 RE | 520 | | LC | |
| 20 | 14.020 | Kutcha Rd | C | 0.3 | 9.39 | | | 5X30m PSC gr+90x2 RE approach | 332 | | Additional | |
| 21 | 14.840 | Kutcha Rd | F | 0.5 | 3 | | | 1x4x2.5 (RC Box) | | 20 | | 2.5 |
| 22 | 15.220 | Village Rd | F | 6.6 | 4.3 | 45 | 3 | 1x5.15x3.6(RC Box) | | 34 | 2.32 | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 23 | 15.485 | Village Rd | C | 5 | 8.4 | 52 | 8 | Mini ROB 1x12x7.5 RC box | 27 | | | |
| 24 | 15.710 | Village Rd | C | 7 | 8.4 | 0 | 3.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 25 | 15.830 | Village Rd | C | 1 | 8.4 | 0 | 4.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 26 | 15.960 | Kutcha Rd | C | 1 | 8.4 | 37 | 4 | Mini ROB 1x12x7.5 RC box | 16 | | | |
| 27 | 16.093 | MDR | F | 1.5 | 9.39 | 45 | 7.5 | 10x30PSC Gr+150x2 RE approach | 584 | | | |
| 28 | 16.247 | Village Rd | F | 5 | 4.3 | 27 | 6.5 | 1x5.15x3.6( RC Box) | | 25 | 0.7 | |
| 29 | 16.506 | Village Rd | F | 0.4 | 4.3 | 54 | 3.5 | 1x5.15x3.6( RC Box) | | 42 | | 3.9 |
| 30 | 16.643 | Village Rd | C | 8 | 8.4 | 36 | 4.4 | Mini ROB 1x12x7.5 RC box | 17 | | | |
| 31 | 16.750 | Village Rd | C | 15 | 8.4 | 16.5 | 6.5 | CT&CR 1x13.25x7.5 RC box | | | 6.1 | |
| 32 | 16.868 | Village Rd | C | 15 | 8.4 | 17 | 3.5 | CT&CR 1x13.25x7.5 RC box | | | 6.43 | |
| 33 | 17.045 | Village Rd | C | 4.5 | 8.4 | 68 | 3.5 | Mini ROB 1x12x7.5 RC box | 49 | | | |
| 34 | 17.167 | Village Rd | F | 3.1 | 4.3 | 25 | 4.5 | 1x5.15x3.6( RC Box) | | 25 | | 1.19 |
| 35 | 17.300 | Kutcha Rd | F | 9.40 | | 20 | 2.5 | Below Viaduct | | | | |
| 36 | 17.866 | MDR | F | 8.5 | | 18 | 8 | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 37 | 18.300 | Kutcha Rd | F | 10.6 | | 0 | 5.5 | Below Viaduct | | | | |
| 38 | 18.594 | Village Rd | F | 9.3 | | 24 | 5 | Below Viaduct | | | | |
| 39 | 18.860 | Kutcha Rd | F | 7.3 | 3 | 0 | 2 | 1x4x2.5 (RC Box) | | 20 | 4.31 | |
| 40 | 19.348 | Village Rd | F | 5 | 4.3 | 28 | 2.5 | 1x5.15x3.6(RC Box) | | 26 | 0.7 | |
| 41 | 19.684 | MDR | F | 1.3 | 9.39 | 23 | 8.5 | 9x30PSC Gr+150x2 RE approach | 561 | 24 | | |
| 42 | 19.910 | Kutcha Rd | C | 6 | 8.4 | 65 | 2 | Mini ROB 1x12x7.5 RC box | 40 | 60 | | |
| 43 | 20.010 | Village Rd | C | 2.2 | 8.4 | 23 | 6 | Mini ROB 1x12x7.5 RC box | 12 | 24 | | |
| 44 | 20.108 | Kutcha Rd | F | 3.2 | 5.2 | 10 | 2 | Below Viaduct | | | | 2.05 |
| 45 | 20.243 | Village Rd | F | 7.5 | 5.8 | 30 | 5 | Below Viaduct | | | | |
| 46 | 20.400 | Kutcha Rd | F | 9.2 | 4.7 | | 3 | Below Viaduct | | | | |
| 47 | 20.586 | Village Rd | C | 9.5 | | 38 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 48 | 20.708 | Village Rd | C | 10 | | 45 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 49 | 20.937 | Village Rd | F | 4.2 | 4.3 | 10 | 3 | 1x5.15x3.6(RC Box) | | 21 | | 0.09 |
| 50 | 21.067 | Kutcha Rd | F | 6.8 | 3 | 10 | 2 | 1x4x2.5 (RC Box) | | 21 | 3.76 | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 51 | 21.176 | Kutcha Rd | F | 7.9 | 3 | 0 | 2 | 1x4x2.5 (RC Box) | | | 4.88 | |
| 52 | 21.543 | MDR | C | 1.5 | 8.4 | 26 | 15 | Mini ROB 1x12x7.5 RC box | 19 | | | |
| 53 | 21.980 | Village Rd | F | 1.3 | 4.3 | 45 | 6 | 1x5.15x3.6( RC Box) | | 34 | | 2.97 |
| 54 | 22.856 | Village Rd | F | 1.9 | 4.3 | 21 | 5.5 | 1x5.15x3.6( RC Box) | | 24 | | 2.43 |
| 55 | 22.900 | MDR | F | 0 | 8.4 | 55 | 7.5 | Mini ROB 1x12x7.5 RC box | 39 | | | |
| 56 | 23.213 | Village Rd | F | 4.2 | 4.3 | 0 | 3.5 | 1x5.15x3.6( RC Box) | | 20 | | |
| 57 | 23.290 | MDR | F | 3.3 | 9.39 | 17 | 5.5 | 12x30PSC Gr+150x2 RE approach | 658 | | | |
| 58 | 23.792 | Village Rd | F | 4.1 | 4.3 | 0 | 4.5 | 1x5.15x3.6( RC Box) | | 20 | | 0.22 |
| 59 | 24.127 | Village Rd | F | 2.3 | 4.15 | 0 | 4.5 | 1x25PSC RH Gr | | 25 | | 1.85 |
| 60 | 24.225 | Village Rd | F | 2.5 | 4.3 | 15 | 3 | 1x5.15x3.6( RC Box) | | 22 | | 1.79 |
| 61 | 24.837 | Village Rd | C | 7.8 | 8.4 | 37 | 5 | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 62 | 24.948 | Village Rd | C | 0.2 | 8.4 | 45 | 3.5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 63 | 25.074 | Kutcha Rd | C | 0.6 | 8.4 | 45 | 2 | Mini ROB 1x12x7.5 RC box | 19 | | | |
| 64 | 25.206 | ODR | C | 13.0 | 8.4 | 5 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW (m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 65 | 25.454 | Village Rd | C | 5 | 8.4 | 0 | 6 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 66 | 25.588 | Kutcha Rd | F | 7 | 3 | 45 | 2.5 | 1x4x2.5 (RC Box) | | 33 | 4 | |
| 67 | 25.840 | Village Rd | C | 8.8 | 8.4 | 0 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 68 | 26.000 | Kutcha Rd | F | 10 | 3 | 0 | 3 | 1x4x2.5 (RC Box) | | 20 | | |
| 69 | 26.367 | ODR | C | 9.6 | 8.4 | 0 | 8 | CT&CR 1x13.25x7.5 RC box | | | | |
| 70 | 26.545 | Village Rd | C | 8.9 | 8.4 | 30 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 71 | 26.785 | Kutcha Rd | F | 8.8 | 3 | 0 | 3 | 1x4x2.5 (RC Box) | | 20 | 5.76 | |
| 72 | 26.883 | Kutcha Rd | F | 8.1 | 3 | 45 | 3 | 1x4x2.5 (RC Box) | | 33 | 5.11 | |
| 73 | 27.065 | Kutcha Rd | F | 3.4 | 3 | 45 | 3 | 1x4x2.5 (RC Box) | | 33 | 0.38 | |
| 74 | 27.651 | Kutcha Rd | C | 10 | 8.4 | 45 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 75 | 27.786 | Village Rd | C | 9.7 | 8.4 | 28 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 76 | 28.100 | Village Rd | C | 15 | 8.4 | 18 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 77 | 28.500 | Village Rd | C | 6 | 8.4 | 45 | 8 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 78 | 28.530 | NH | C | 4 | 8.4 | 45 | 11 | Mini ROB 1x12x7.5 RC box | 35 | | | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 79 | 28.550 | Kutcha Rd | C | 4.2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | | | | |
| 80 | 29.005 | Village Rd | F | 12 | 5.8 | 10 | 3 | Below Viaduct | | | | |
| 81 | 29.533 | Village Rd | C | 1.1 | 8.4 | 45 | 5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 82 | 29.890 | Village Rd | C | 8.6 | 8.4 | 45 | 3.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 83 | 30.043 | Kutcha Rd | C | 12 | 8.4 | 0 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 84 | 30.100 | Kutcha Rd | C | 11 | 8.4 | 0 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 85 | 30.270 | Kutcha Rd | F | 1.2 | 4.3 | 0 | 3.5 | 1x4x2.5 (RC Box) | | 20 | | 3.1 |
| 86 | 30.518 | Village Rd | C | 0.4 | 8.4 | 0 | 4.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 87 | 30.888 | Village Rd | C | 4.1 | 8.4 | 10 | 4 | Mini ROB 1x12x7.5 RC box | 8.5 | | | |
| 88 | 31.242 | Village Rd | C | 14 | 8.4 | 0 | 6 | CT&CR 1x13.25x7.5 RC box | | | | |
| 89 | 31.855 | SH | C | 11 | 8.4 | 10 | 11 | CT&CR 1x13.25x7.5 RC box | | | | |
| 90 | 32.343 | Village Rd | F | 6.6 | 4.3 | 25 | 4 | 1x5.15x3.6RC Box | | 25 | 2.27 | |
| 91 | 32.582 | MDR | C | 3.5 | 8.4 | 18 | 7.5 | Mini ROB 1x12x7.5 RC box | 17 | | | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 92 | 32.917 | Village Rd | C | 5.1 | 8.4 | 0 | 3 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 93 | 32.996 | Village Rd | C | 9.2 | 8.4 | 0 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 94 | 33.185 | Kutcha Rd | C | 2.2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 95 | 33.417 | MDR | C | 0.3 | 4.3 | 0 | 4.5 | 1x10x5.5 (RC Box) | | 20 | | 4.6 |
| 96 | 34.139 | Village Rd | C | 8.7 | 8.4 | 28 | 4.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 97 | 34.216 | Village Rd | F | 1 | 4.3 | 45 | 7 | 1x5.15x3.6RC Box | | 34 | | 3.26 |
| 98 | 35.377 | Kutcha Rd | C | 18 | 8.4 | 0 | 2 | CT&CR 1x13.25x7.5 RC box | | | | |
| 99 | 35.806 | Village Rd | C | 17 | 8.4 | 45 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 100 | 36.200 | Village Rd | F | 8.3 | 4.3 | 0 | 3 | 1x5.15x3.6RC Box | | 20 | 4 | |
| 101 | 36.482 | Village Rd | F | 6.3 | 4.3 | 0 | 3 | 1x5.15x3.6RC Box | | 20 | | |
| 102 | 36.605 | Village Rd | F | 13 | 5.8 | 30 | 3 | Below Viaduct | | | | |
| 103 | 37.050 | SH | C | 20 | 8.4 | 30 | 7.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 104 | 37.873 | Village Rd | F | 9 | 4.3 | 0 | 4.5 | 1x5.15x3.6( RC Box) | | 20 | 4.7 | |
| 105 | 38.336 | ODR | C | 3.9 | 8.4 | 10 | 4.5 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 106 | 38.956 | Village Rd | F | 15 | 5.8 | 0 | 3.5 | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/ Cutting/ Cut &Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 107 | 39.208 | NH | F | 9.3 | 7.7 | 45 | 8 | Below Viaduct | | | | |
| 108 | 39.524 | MDR | F | 7.3 | 6.7 | 0 | 5 | 1x10x5.5 (RC Box) | | 20 | 0.6 | |
| 109 | 39.916 | Village Rd | C | 7 | 8.4 | 45 | 2 | Mini ROB 1x12x7.5 RC box | 22 | | | |

## 8.18 BALLAST TRANSITION:

On the transition between structures and earthworks, suitable measures should be taken both to reduce differential settlement and to ensure that there is gradual transition of support stiffness. For defining the transition zone, the following aspects should be taken into account;

- Type of structure.
- The constructive process.
- Operational speed on the track.
- The height of the structure.
- The different allowable settlement; The long-term settlement of the foundation soil, of the back fill and the structure should comply with the allowable differential settlement of the railway track.

For good driving over the transition following aspects need special care during construction.

- special care should be taken in the compaction works, mainly in the vicinity of the structure.
- selected compactable backfill material should be used. A percentage of cement can also be added to upgrade the material near the structure.
- A drainage layer must be incorporated behind the structure.

The transition region from ballast less track to ballasted track (from tunnel to cutting) are to be properly designed for achieving good ridership as shown in the **Figure below**;

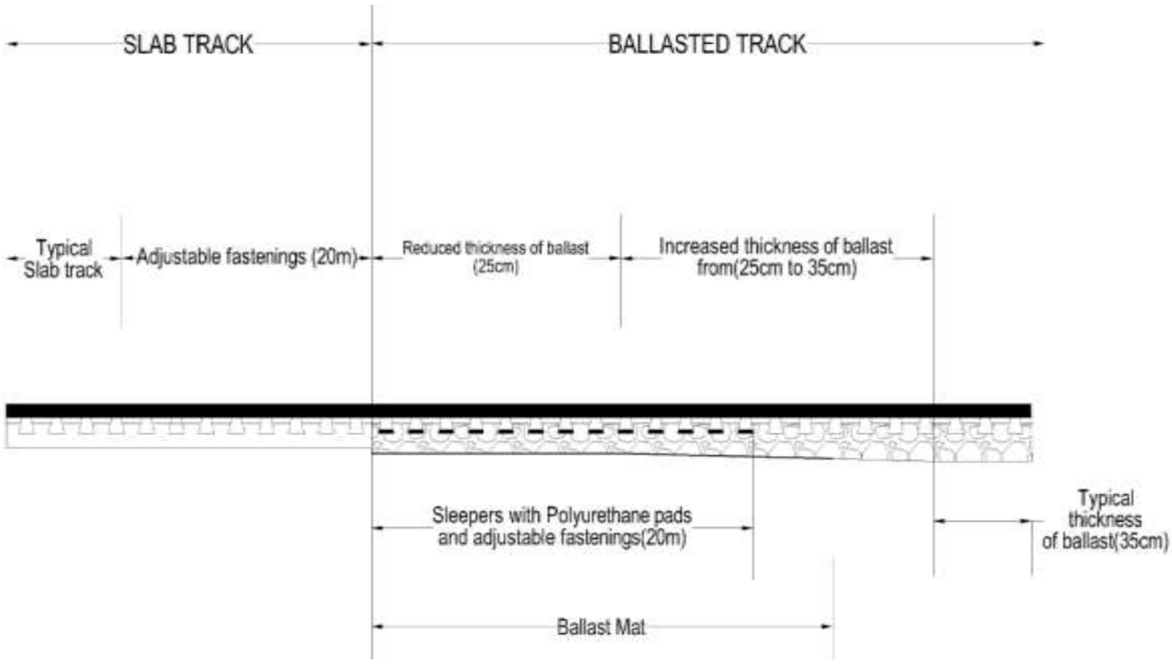


**Figure 8-118: Details of Ballast Transition from ballast less track to ballasted track (Tunnel to Cutting)**

## 8.19 PROTECTION OF STRUCTURES FROM STRAY CURRENT:

Stray current corrosion is fundamentally different from other (non-stray current) types of corrosion in that stray current corrosion is an electrolysis process. In the electrolysis process, the external current (stray current) alone drives metal atoms into electrolyte as water-soluble ions. The environmental factors such as oxygen concentration, chloride, and pH that are so critical to natural corrosion processes are no longer relevant. The extent of damage or loss of metal is directly proportional to the magnitude of stray current leaving the structure at the point of discharge. Stray current corrosion will be concentrated at certain location that leads to the lowest electrical resistance in the current circuit.

The corrosion control system is to be designed by DDC to mitigate the potential effects of stray currents by adopting suitable measures. Some of the measures are described hereunder;

- Connections shall be provided to enable electrical bonding of the inner reinforcement across isolation joints.
- Facilities for jointing any or all of the connections shall be provided.
- Reinforcement for segmental concrete lining shall be designed such that no electrical continuity will exist across the circle joint.
- SGI segments shall be bonded to mitigate potential stray current effects.
- Cathodic protection should be applied to all the pipes inside the tunnel.

- Bracket for the pipes or cable should be taken care of its insulation.

## 8.20 GRADE OF CONCRETE AND STEEL FOR BRIDGES AND OTHER STRUCTURES:

### 8.20.1 Concrete:-

It is proposed to carry out construction work with design mix concrete. Computerized Automatic Batching Plants are to be installed. Following grades of concrete are proposed for various members as per design requirement/durability considerations. However this are to be reviewed by DDC during construction.

i) Piles: M-35
ii) Open: M-35
iii) Pile cap – M60
iv) Piers & Pier caps: M-60
v) All pre-cast elements for viaduct and stations: M-60
vi) Tunnel segments: M-45
vii) Other miscellaneous structures: M-60

The higher vibration due to SilverLine can be controlled by increasing the stiffness of the structures. This has been achieved mainly by adopting high strength high performance concrete of M60 mix, similar to the mix adopted in Mumbai-Worli Sea Link project. The proportion of this GREEN / Sustainable concrete, adopted for estimate purpose, is given in the **Tables 8-32 to 8-34** for guidance.

**Table 8-32: Typical concrete mix design**

| Material | Pre-cast I- girder | Pile Caps, Piers and Pier Caps |
|---|---|---|
| Portland Cement (53 grade) | 420 kg/m$^3$ | 300 kg/m$^3$ |
| Microsilica / Silica Fume | 42 kg/m$^3$ | 40 kg/m$^3$ |
| Fly ash (ASTM class F) | Nil | 196 kg/m$^3$ |
| Coarse aggregate, 20mm | 540 kg/m$^3$ | 570 kg/m$^3$ |
| Coarse aggregate, 10mm | 460 kg/m$^3$ | 500 kg/m$^3$ |
| M Sand | 920 kg/m$^3$ | 750 kg/m$^3$ |
| Admixture | 14.8 liters/m$^3$ | 13.4 liters/m$^3$ |
| Water (liters/m$^3$) | 127 (0.27 w/p ratio) | 134 (0.25 w/p ratio) |

*Note:-The fly ash is not allowed for PSC structures*

The characteristics of the above mix are tabulated below;

**Table 8-33: Grade M-60 concrete Compressive Strength Results (Typical)**

| Age | Precast Box Girder | Pile caps & piers |
|---|---|---|
| 20 hr | 26.0 MPa | - |
| 3 day | 52.0 MPa | 39.5 MPa |
| 7 day | 64.0 MPa | 56.0 MPa |
| 28 day | 75.0 MPa | 75.5 MPa |

**Table 8-34: Concrete durability results**

| Test | M- 60 Pile & piers |
|---|---|
| RCPT ASTM C 1202 | 600 Coulombs |
| Permeability DIN 1048 | Nil |
| Max. Core temperature | $68^0$ C |
| Max. temperature difference between Core/ Surface | < $20^0$ C |

*Note:* - For all main structures, permeability test of concrete is recommended to ensure to provide impermeable concrete. Suitable call to be taken during execution.

### 8.20.2 Reinforcement and Pre-stressed Steel :-

Fe 500D steel will be used as reinforcement bars. For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 T 13 and 19T 13 or 19 K 15 is recommended (conforming to IS:14268).

## 8.21 CODES AND REPORTS REFERRED:

### 1) Hierarchy of Codes are as under:

- For railway loading related issues:-
    I. IRS codes
    II. UIC Codes
    III. Euro Codes

IV. Any other code, which covers railway loadings.

- For other Design/detailing related issue:-
  i. IRS
  ii. IRC
  iii. Euro Code
  iv. AASHTO

However, final decisions on various codes to be adopted has to be made through a Design Bridge Manual prepared eventually in the project.

**2) IRC Codes (With Latest Versions):-**

- IRC: 5 Standard Specification & code of practice for Road Bridges - General Features of Designs
- IRC: 6 Standard Specification & code of practice for Road Bridges - Loads & Stresses
- IRC: 22 Standard Specification & code of practice for Road Bridges, Section VI – Composite Construction for Road Bridges
- IRC: 24 Standard Specification & code of practice for Road Bridges, Section V- Steel Road Bridges
- IRC: 78 Standard Specification & code of practice for Road Bridges – Section Foundation & Sub-Structure
- IRC: 83(I) Standard Specification & code of practice for Road Bridges, Part-I Metallic Bearings
- IRC: 83(II) Standard Specification & code of practice for Road Bridges, Part-II Elastomeric Bearings
- IRC: 83(III) Standard Specification & code of practice for Road Bridges, Part-III POT, POT-cum PT; TE, Pin and Metallic Guide Bearings
- IRC: 83(IV) Standard Specification & code of practice for Road Bridges, Part, IV Spherical and Cylindrical Bearings.
- IRC: 112 Code of practice for Concrete Bridges

**3) IS Codes (With Latest Versions):-**

- IS: 269 Specs for Ordinary and Low Head Portland cement
- IS: 383 Specs for coarse and fine aggregates from natural sources for concrete
- IS: 432 Specs for Mild steel and medium tensile steel bars(Part 1)
- IS: 456 Plain and reinforced concrete – code of practice
- IS: 800 Code of practice for General Construction Steel
- IS: 875 Code of practice for Design loads Part 1,2,3,4& 5(Other than Earthquake)

- IS: 1080 Design and construction of shallow foundations in soils (other than raft ring and shell)
- IS: 1343 Code of practice for Pre-stressed concrete – based essentially on CP-110
- IS: 1364 Hexagon Head Bolts, Screw & nuts of product grades A&B Part 1(part 1 Hexagon, Head bolts (size range M 1:6 to M64)
- IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces code of practice
- IS: 1489 Specifications for Portland pozzolana cement (Fly ash based)
- IS: 1786 High strength deformed steel bars and wires for concrete reinforcement
- IS: 1893 Criteria for Earthquake Resistant Design of structures
- IS: 1904 Design and construction of Foundations in soils: general requirement
- IS: 1905 Code of practice for structural use of unreinforced masonry
- IS: 2062 Specification for weldable structural steel
- IS: 2502 Code of practice for Bending and Fixing of Bars for Concrete Reinforcement
- IS: 2911 Code of practice for Design & construction of Pile foundation Part 1 (Sec 1 ) Concrete piers Section 2 Board Cast-in-situ-piles (with amendments)
- IS: 2911 Code of practice for Design& Construction of Pile foundations Part 4 Load test on piles
- IS: 2950 Design & construction of raft foundations
- IS 3935 Code of practice for Composite Construction
- IS: 4326 Code of practice for Earthquake resistant design and construction of Buildings
- IS: 4923 Hollow steel sections for structural use-specification
- IS: 8009 Calculation of settlement of shallow foundations
- IS: 8112 Specification for 43 grade ordinary Portland cement
- IS: 9103 Specification of concrete admixtures
- IS 11384 Code of practice for Composite construction in Structural Steel and concrete
- IS: 12070 Code of practice for Design& Construction of shallow foundation on Rocks
- IS: 12269 Specification for 53 grade ordinary Portland cement
- IS: 14268 Uncoated Stress Relieved Low relaxation Seven– ply Strands for Prestressed concrete
- IS: 14593 Design& Construction of Bored Cast-in-situ Piles Founded on Rocks.

**4. Bs Codes (With Latest Version)**

- BS:4447 Specifications for the performance of prestressing anchorage for post-tensioned concrete
- BS: 4486 Specifications for high tensile bars used for prestressing
- BS: 5400 Code of practice for Design of Concrete Bridges Part 4-1990-Part2-2006
- BS: 8006 Code of practice for strengthened reinforced soils and other fills-1995
- BS: 8007 Design of concrete structures for retaining liquids.

**5. Others (With Latest Versions)**

- UIC: 776-1R Loads to consider in Railway Bridge Design- UIC 719 R
- UIC: 776-1R Deformation of Bridges
- UIC: 772 Then International Union Railway Publication
- UIC: 774- 3R Rail structure interaction
- CEB_FIB Model Code 1990 for Concrete Structures
- The design relating to Fire safety and escape shall be in accordance with the requirements of NFPA 130 standard for fixed guide way system
- FIP Recommendations for the acceptance of post tensioned systems
- M.O.R.T and Highways specifications
- Euro code 0 Basis of Structural Design
- Euro code 1 Actions on Structures – Part 2-Traffic Loads on Bridges
- Euro code 2 Design of concrete structures- Part 1.1: General Rules and Rules for Building
- Euro code 2 Design of concrete structures- Part 2, Concrete Bridges- Design and Detailing Rules
- ACI 358:IR-92 (American Concrete Institute) for assessment of dynamic impact for transit Guide ways
- RDSO Guidelines for carrying out RSI (Version 2.0 ) issued in January 2015 BS-111 version-3 issued in January 2015
- BS 89 HPC

## ANNEXURE.1 Complete list of ROBs/RUBs crossing the alignment

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1 | 1.842 | Village Rd | F | 6.9 | 4.3 | 40 | 4.5 | 1X5.15X3.6 (RC Box) | | 31.1 | 2.57 | |
| 2 | 2.238 | Village Rd | F | 5.8 | 4.3 | 55 | 5 | 1X5.15X3.6 (RC Box) | | 43 | 1.5 | |
| 3 | 2.425 | Village Rd | F | 6.2 | 4.3 | 58 | | 1X5.15X3.6 (RC Box) | | 47 | 1.9 | |
| 4 | 4.326 | ODR | F | 2.4 | 9.39 | 0 | 8 | 12x30 PSC Gr+150x2 RE approach | 650 | | LC/11m from CL to CL of nearest track | |
| 5 | 5.050 | Kutcha Rd | F | 2.6 | 3 | 17 | | 1x4x2.5 (RC Box) | | 53 | Additional | 0.42 |
| 6 | 5.600 | Kutcha Rd | F | 2.9 | 3 | 0 | | 1x4x2.5 (RC Box) | | 50 | Additional | 0.12 |
| 7 | 6.080 | Kutcha Rd | F | 1.5 | 3 | 30 | 2 | 1x4x2.5 (RC Box) | | 26 | | 1.5 |
| 9 | 6.425 | Village Rd | F | 0.8 | 4.3 | | | 1x5.15x3.6(RC Box) | | 50 | Additional | 3.55 |
| 10 | 6.850 | Kutcha Rd | F | 0.4 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 2.6 |
| 11 | 7.207 | Modified ROB | C | 0.3 | 7.16 | 25 | 12 | Mini ROB 2x12x7.5 RC box | | 20 | VC 5.77 considered | 0.42 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 12 | 7.750 | Kutcha Rd | F | 0.8 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 2.2 |
| 13 | 8.200 | Kutcha Rd | F | 0.7 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 2.34 |
| 14 | 8.868 | ODR | F | 1 | 9.39 | 15 | 7 | 9x30PSC Gr+150x2 RE approach | 570 | | LC | |
| 15 | 10.017 | ODR | F | 0 | 9.39 | 38 | 7 | 7x30PSC Gr+150x2 RE approach | 520 | | LC | |
| 16 | 10.580 | Kutcha Rd | F | 2.1 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 0.88 |
| 17 | 11.200 | Kutcha Rd | F | 1.5 | 3 | | | 1x4x2.5 (RC Box) | | 50 | Additional | 1.5 |
| 18 | 11.954 | ODR | F | 3.3 | 9.39 | 20 | 4.5 | 13x30PSC gr+150x2 RE approach | 683 | | LC | |
| 19 | 13.454 | MDR | C | 0.5 | 9.39 | 27 | 6.5 | 7x30PSC gr+150x2 RE | 520 | | LC | |
| 20 | 14.020 | Kutcha Rd | C | 0.3 | 9.39 | | | 5X30m PSC gr+90x2 RE approach | 332 | | Additional | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 21 | 14.840 | Kutcha Rd | F | 0.5 | 3 | | | 1x4x2.5 (RC Box) | | 20 | | 2.5 |
| 22 | 15.220 | Village Rd | F | 6.6 | 4.3 | 45 | 3 | 1x5.15x3.6( RC Box) | | 34 | 2.32 | |
| 23 | 15.485 | Village Rd | C | 5 | 8.4 | 52 | 8 | Mini ROB 1x12x7.5 RC box | 27 | | | |
| 24 | 15.710 | Village Rd | C | 7 | 8.4 | 0 | 3.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 25 | 15.830 | Village Rd | C | 1 | 8.4 | 0 | 4.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 26 | 15.960 | Kutcha Rd | C | 1 | 8.4 | 37 | 4 | Mini ROB 1x12x7.5 RC box | 16 | | | |
| 27 | 16.093 | MDR | F | 1.5 | 9.39 | 45 | 7.5 | 10x30PSC Gr+150x2 RE approach | 584 | | | |
| 28 | 16.247 | Village Rd | F | 5 | 4.3 | 27 | 6.5 | 1x5.15x3.6( RC Box) | | 25 | 0.7 | |
| 29 | 16.506 | Village Rd | F | 0.4 | 4.3 | 54 | 3.5 | 1x5.15x3.6( RC Box) | | 42 | | 3.9 |
| 30 | 16.643 | Village Rd | C | 8 | 8.4 | 36 | 4.4 | Mini ROB 1x12x7.5 RC box | 17 | | | |
| 31 | 16.750 | Village Rd | C | 15 | 8.4 | 16.5 | 6.5 | CT&CR 1x13.25x7.5 RC box | | | 6.1 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 32 | 16.868 | Village Rd | C | 15 | 8.4 | 17 | 3.5 | CT&CR 1x13.25x7.5 RC box | | | 6.43 | |
| 33 | 17.045 | Village Rd | C | 4.5 | 8.4 | 68 | 3.5 | Mini ROB 1x12x7.5 RC box | 49 | | | |
| 34 | 17.167 | Village Rd | F | 3.1 | 4.3 | 25 | 4.5 | 1x5.15x3.6( RC Box) | | 25 | | 1.19 |
| 35 | 17.300 | Kutcha Rd | F | 9.40 | 4.7 | 20 | 2.5 | Below Viaduct | | | | |
| 36 | 17.866 | MDR | F | 8.5 | 7.7 | 18 | 8 | Below Viaduct | | | | |
| 37 | 18.300 | Kutcha Rd | F | 10.6 | 4.7 | 0 | 5.5 | Below Viaduct | | | | |
| 38 | 18.594 | Village Rd | F | 9.3 | 5.8 | 24 | 5 | Below Viaduct | | | | |
| 39 | 18.860 | Kutcha Rd | F | 7.3 | 3 | 0 | 2 | 1x4x2.5 (RC Box) | | 20 | 4.31 | |
| 40 | 19.348 | Village Rd | F | 5 | 4.3 | 28 | 2.5 | 1x5.15x3.6( RC Box) | | 26 | 0.7 | |
| 41 | 19.684 | MDR | F | 1.3 | 9.39 | 23 | 8.5 | 9x30PSC Gr+150x2 RE approach | 561 | 24 | | |
| 42 | 19.910 | Kutcha Rd | C | 6 | 8.4 | 65 | 2 | Mini ROB 1x12x7.5 RC box | 40 | 60 | | |
| 43 | 20.010 | Village Rd | C | 2.2 | 8.4 | 23 | 6 | Mini ROB 1x12x7.5 RC box | 12 | 24 | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 44 | 20.108 | Kutcha Rd | F | 3.2 | 5.2 | 10 | 2 | Below Viaduct | | | | 2.05 |
| 45 | 20.243 | Village Rd | F | 7.5 | 5.8 | 30 | 5 | Below Viaduct | | | | |
| 46 | 20.400 | Kutcha Rd | F | 9.2 | 4.7 | | 3 | Below Viaduct | | | | |
| 47 | 20.586 | Village Rd | C | 9.5 | 8.4 | 38 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 48 | 20.708 | Village Rd | C | 10 | 8.4 | 45 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 49 | 20.937 | Village Rd | F | 4.2 | 4.3 | 10 | 3 | 1x5.15x3.6( RC Box) | | 21 | | 0.09 |
| 50 | 21.067 | Kutcha Rd | F | 6.8 | 3 | 10 | 2 | 1x4x2.5 (RC Box) | | 21 | 3.76 | |
| 51 | 21.176 | Kutcha Rd | F | 7.9 | 3 | 0 | 2 | 1x4x2.5 (RC Box) | | | 4.88 | |
| 52 | 21.543 | MDR | C | 1.5 | 8.4 | 26 | 15 | Mini ROB 1x12x7.5 RC box | 19 | | | |
| 53 | 21.980 | Village Rd | F | 1.3 | 4.3 | 45 | 6 | 1x5.15x3.6( RC Box) | | 34 | | 2.97 |
| 54 | 22.856 | Village Rd | F | 1.9 | 4.3 | 21 | 5.5 | 1x5.15x3.6( RC Box) | | 24 | | 2.43 |
| 55 | 22.900 | MDR | F | 0 | 8.4 | 55 | 7.5 | Mini ROB 1x12x7.5 RC box | 39 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 56 | 23.213 | Village Rd | F | 4.2 | 4.3 | 0 | 3.5 | 1x5.15x3.6(RC Box) | | 20 | | |
| 57 | 23.290 | MDR | F | 3.3 | 9.39 | 17 | 5.5 | 12x30PSC Gr+150x2 RE approach | 658 | | | |
| 58 | 23.792 | Village Rd | F | 4.1 | 4.3 | 0 | 4.5 | 1x5.15x3.6(RC Box) | | 20 | | 0.22 |
| 59 | 24.127 | Village Rd | F | 2.3 | 4.15 | 0 | 4.5 | 1x25PSC RH Gr | | 25 | | 1.85 |
| 60 | 24.225 | Village Rd | F | 2.5 | 4.3 | 15 | 3 | 1x5.15x3.6(RC Box) | | 22 | | 1.79 |
| 61 | 24.837 | Village Rd | C | 7.8 | 8.4 | 37 | 5 | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 62 | 24.948 | Village Rd | C | 0.2 | 8.4 | 45 | 3.5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 63 | 25.074 | Kutcha Rd | C | 0.6 | 8.4 | 45 | 2 | Mini ROB 1x12x7.5 RC box | 19 | | | |
| 64 | 25.206 | ODR | C | 13.0 | 8.4 | 5 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 65 | 25.454 | Village Rd | C | 5 | 8.4 | 0 | 6 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 66 | 25.588 | Kutcha Rd | F | 7 | 3 | 45 | 2.5 | 1x4x2.5 (RC Box) | | 33 | 4 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 67 | 25.840 | Village Rd | C | 8.8 | 8.4 | 0 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 68 | 26.000 | Kutcha Rd | F | 10 | 3 | 0 | 3 | 1x4x2.5 (RC Box) | | 20 | 7 | |
| 69 | 26.367 | ODR | C | 9.6 | 8.4 | 0 | 8 | CT&CR 1x13.25x7.5 RC box | | | | |
| 70 | 26.545 | Village Rd | C | 8.9 | 8.4 | 30 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 71 | 26.785 | Kutcha Rd | F | 8.8 | 3 | 0 | 3 | 1x4x2.5 (RC Box) | | 20 | 5.76 | |
| 72 | 26.883 | Kutcha Rd | F | 8.1 | 3 | 45 | 3 | 1x4x2.5 (RC Box) | | 33 | 5.11 | |
| 73 | 27.065 | Kutcha Rd | F | 3.4 | 3 | 45 | 3 | 1x4x2.5 (RC Box) | | 33 | 0.38 | |
| 74 | 27.651 | Kutcha Rd | C | 10 | 8.4 | 45 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 75 | 27.786 | Village Rd | C | 9.7 | 8.4 | 28 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 76 | 28.100 | Village Rd | C | 15 | 8.4 | 18 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 77 | 28.500 | Village Rd | C | 6 | 8.4 | 45 | 8 | Mini ROB 1x12x7.5 RC box | 25 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 78 | 28.530 | NH | C | 4 | 8.4 | 45 | 11 | Mini ROB 1x12x7.5 RC box | 35 | | | |
| 79 | 28.550 | Kutcha Rd | C | 4.2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | | | | |
| 80 | 29.005 | Village Rd | F | 12 | 5.8 | 10 | 3 | Below Viaduct | | | | |
| 81 | 29.533 | Village Rd | C | 1.1 | 8.4 | 45 | 5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 82 | 29.890 | Village Rd | C | 8.6 | 8.4 | 45 | 3.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 83 | 30.043 | Kutcha Rd | C | 12 | 8.4 | 0 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 84 | 30.100 | Kutcha Rd | C | 11 | 8.4 | 0 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 85 | 30.270 | Kutcha Rd | F | 1.2 | 4.3 | 0 | 3.5 | 1x4x2.5 (RC Box) | | 20 | | 3.1 |
| 86 | 30.518 | Village Rd | C | 0.4 | 8.4 | 0 | 4.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 87 | 30.888 | Village Rd | C | 4.1 | 8.4 | 10 | 4 | Mini ROB 1x12x7.5 RC box | 8.5 | | | |
| 88 | 31.242 | Village Rd | C | 14 | 8.4 | 0 | 6 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 89 | 31.855 | SH | C | 11 | 8.4 | 10 | 11 | CT&CR 1x13.25x7.5 RC box | | | | |
| 90 | 32.343 | Village Rd | F | 6.6 | 4.3 | 25 | 4 | 1x5.15x3.6 RC Box | | 25 | 2.27 | |
| 91 | 32.582 | MDR | C | 3.5 | 8.4 | 18 | 7.5 | Mini ROB 1x12x7.5 RC box | 17 | | | |
| 92 | 32.917 | Village Rd | C | 5.1 | 8.4 | 0 | 3 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 93 | 32.996 | Village Rd | C | 9.2 | 8.4 | 0 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 94 | 33.185 | Kutcha Rd | C | 2.2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 95 | 33.417 | MDR | C | 0.3 | 4.3 | 0 | 4.5 | 1x10x5.5 (RC Box) | | 20 | | 4.6 |
| 96 | 34.139 | Village Rd | C | 8.7 | 8.4 | 28 | 4.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 97 | 34.216 | Village Rd | F | 1 | 4.3 | 45 | 7 | 1x5.15x3.6 RC Box | | 34 | | 3.26 |
| 98 | 35.377 | Kutcha Rd | C | 18 | 8.4 | 0 | 2 | CT&CR 1x13.25x7.5 RC box | | | | |
| 99 | 35.806 | Village Rd | C | 17 | 8.4 | 45 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 100 | 36.200 | Village Rd | F | 8.3 | 4.3 | 0 | 3 | 1x5.15x3.6 RC Box | | 20 | 4 | |
| 101 | 36.482 | Village Rd | F | 6.3 | 4.3 | 0 | 3 | 1x5.15x3.6 RC Box | | 20 | 2 | |
| 102 | 36.605 | Village Rd | F | 13 | 5.8 | 30 | 3 | Below Viaduct | | | | |
| 103 | 37.050 | SH | C | 20 | 8.4 | 30 | 7.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 104 | 37.873 | Village Rd | F | 9 | 4.3 | 0 | 4.5 | 1x5.15x3.6( RC Box) | | 20 | 4.7 | |
| 105 | 38.336 | ODR | C | 3.9 | 8.4 | 10 | 4.5 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 106 | 38.956 | Village Rd | F | 15 | 5.8 | 0 | 3.5 | Below Viaduct | | | | |
| 107 | 39.208 | NH | F | 9.3 | 7.7 | 45 | 8 | Below Viaduct | | | | |
| 108 | 39.524 | MDR | F | 7.3 | 6.7 | 0 | 5 | 1x10x5.5 (RC Box) | | 20 | 0.6 | |
| 109 | 39.916 | Village Rd | C | 7 | 8.4 | 45 | 2 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 110 | 40.126 | Village Rd | F | 4.9 | 4.3 | 0 | 4 | 1x5.15x3.6( RC Box) | | 20 | 0.6 | |
| 111 | 40.419 | Village Rd | C | 8 | 8.4 | 10 | 3 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 112 | 40.878 | MDR | C | 4.3 | 8.4 | 45 | 7.5 | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 113 | 41.700 | Village Rd | F | 1.2 | 4.3 | 0 | 3 | 1x5.15x3.6( RC Box) | | 20 | | 3.15 |
| 114 | 41.900 | Kutcha Rd | C | 8.7 | 8.4 | 0 | 14 | CT&CR 1x13.25x7.5 RC box | | | | |
| 115 | 41.983 | MDR | C | 2.9 | 8.4 | 5 | 5 | Mini ROB 1x12x7.5 RC box | 13 | | | |
| 116 | 42.349 | Village Rd | C | 8.2 | 8.4 | 15 | 7 | Mini ROB 1x12x7.5 RC box | 9.8 | | | |
| 117 | 42.894 | MDR | C | 4.8 | 8.4 | 0 | 5.5 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 118 | 43.323 | Village Rd | C | 1.3 | 8.4 | 20 | 3.5 | Mini ROB 1x12x7.5 RC box | 11 | | | |
| 119 | 43.472 | Village Rd | F | 8.1 | 4.3 | 20 | 3 | 1x5.15x3.6( RC Box) | | 26 | 3.8 | |
| 120 | 43.674 | Kutcha Rd | F | 6.6 | 4.7 | 45 | 3 | 1x4x2.5 (RC Box) | | 33 | 1.9 | |
| 121 | 43.842 | Village Rd | C | 4.9 | 8.4 | 45 | 3.5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 122 | 43.964 | Village Rd | C | 7,02 | 8.4 | 56 | 7 | Mini ROB 1x12x7.5 RC box | 31 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 123 | 44.714 | Kutcha Rd | C | 17 | 8.4 | 10 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 124 | 44.783 | NH | C | 14 | 8.4 | 31 | 11 | CT&CR 1x13.25x7.5 RC box | | | | |
| 125 | 45.043 | Village Rd | C | 3.6 | 8.4 | 20 | 5.5 | Mini ROB 1x12x7.5 RC box | 11 | | | |
| 126 | 45.549 | Village Rd | F | 12 | 5.8 | 21 | 8 | Below Viaduct | | | | |
| 127 | 45.730 | ODR | F | 5 | 5.1 | 57 | 6.5 | 1x5.15x4.5 RC Box | | 46 | | 0.1 |
| 128 | 46.150 | ODR | C | 1.7 | 8.4 | 5 | 8 | Mini ROB 1x12x7.5 RC box | 7.2 | | | |
| 129 | 46.346 | Village Rd | C | 5.5 | 8.4 | 0 | 3 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 130 | 46.620 | Village Rd | C | 1 | 8.4 | 0 | 3 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 131 | 46.775 | MDR | F | 3.3 | 9.39 | 13 | 12 | 12x30PSC Gr+150x2 RE approach | 658 | | | |
| 132 | 47.031 | Village Rd | F | 9.8 | 4.3 | 0 | 3 | Below Viaduct | | | 5.5 | |
| 133 | 47.225 | ODR | F | 3.5 | 9.39 | 0 | 5 | 12x30PSC Gr+150x2 RE approach | 665 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cut over | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 134 | 47.644 | Village Rd | F | 4.3 | 4.3 | 14 | 3 | 1x5.15x3.6 RC Box | | 22 | 0 | |
| 135 | 47.736 | Village Rd | F | 6.4 | 4.3 | 10 | 3 | 1x5.15x3.6 RC Box | | 21 | 2.1 | |
| 136 | 47.886 | Village Rd | F | 5 | 4.3 | 10 | 3 | 1x5.15x3.6 RC Box | | 21 | 0.7 | |
| 137 | 47.986 | Village Rd | F | 6 | 4.3 | 45 | 5 | 1x5.15x3.6 RC Box | | 34 | 1.7 | |
| 138 | 48.275 | Kutcha Rd | F | 5.6 | 3 | 35 | 3 | 1x4x2.5 (RC Box) | | 28 | 2.6 | |
| 139 | 48.410 | Village Rd | F | 4 | 4.3 | 50 | 6.5 | 1x5.15x 3.6 RC Box | | 38 | | 0.3 |
| 140 | 48.519 | MDR | F | 0.4 | 9.39 | 16 | 15 | 7x30PSC Gr+150x2 RE approach | 514 | | | |
| 141 | 49.123 | Village Rd | F | 9.3 | 5.8 | 45 | 4.5 | Below Viaduct | | | | |
| 142 | 49.413 | Village Rd | F | 10 | 5.8 | 45 | 6.5 | Below Viaduct | | | | |
| 143 | 50.030 | Village Rd | C | 5.4 | 8.4 | 0 | 6.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 144 | 50.234 | Village Rd | F | 4.1 | 4.3 | 30 | 4.5 | 1x5.15x3.6 RC Box | | 27 | | 0.2 |
| 145 | 50.372 | NH | F | 14 | 6.7 | 57 | 14 | Below Viaduct | | | | |
| 146 | 50.542 | Village Rd | F | 8.2 | 5.8 | 58 | 3.5 | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 147 | 50.645 | Village Rd | F | 1.6 | 4.3 | 45 | 6.7 | 1x5.15x3.6 RC Box | | 34 | | 2.7 |
| 148 | 50.874 | Village Rd | C | 9.3 | 8.4 | 27 | 6 | CT&CR 1x13.25x7.5 RC box | | | | |
| 149 | 51.156 | Village Rd | C | 7.3 | 8.4 | 36 | 4.5 | Mini ROB 1x12x7.5 RC box | 17 | | | |
| 150 | 51.746 | Village Rd | F | 11 | 5.8 | 0 | 4 | Below Viaduct | | | | |
| 151 | 51.858 | Village Rd | F | 10 | 5.8 | 0 | 4 | Below Viaduct | | | | |
| 152 | 51.969 | Kutcha Rd | F | 9 | 4.7 | 0 | 3 | Below Viaduct | | | | |
| 153 | 52.044 | Kutcha Rd | F | 8.6 | 4.7 | 45 | 3.5 | Below Viaduct | | | | |
| 154 | 52.112 | Kutcha Rd | F | 8.2 | 4.7 | 15 | 3 | Below Viaduct | | | | |
| 155 | 52.177 | Village Rd | F | 8 | 5.8 | 0 | 3 | Below Viaduct | | | | |
| 156 | 52.281 | Village Rd | F | 5.3 | 4.3 | 27 | 6.5 | 1x5.15x3.6 RC Box | | 25 | 1.03 | |
| 157 | 52.357 | Kutcha Rd | F | 0.6 | 3 | 0 | 4 | 1x4x2.5 (RC Box) | | 20 | | 2.4 |
| 158 | 52.464 | Village Rd | C | 5.5 | 8.4 | 45 | 4 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 159 | 52.564 | Village Rd | C | 8.9 | 8.4 | 22 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 160 | 52.654 | MDR | C | 9.6 | 8.4 | 40 | 17 | CT&CR 1x13.25x7.5 RC box | | | | |
| 161 | 52.732 | Village Rd | C | 6,83 | 8.4 | 43 | 4 | Mini ROB 1x12x7.5 RC box | 21 | | | |
| 162 | 52.779 | Kutcha Rd | C | 3.3 | 8.4 | 5 | 3 | Mini ROB 1x12x7.5 RC box | 7.2 | | | |
| 163 | 53.350 | Village Rd | F | 8 | 5.8 | 0 | 7 | Below Viaduct | | | | |
| 164 | 53.728 | Village Rd | F | 9 | 5.8 | 0 | 9 | Below Viaduct | | | | |
| 165 | 54.371 | Village Rd | F | 7.3 | 5.8 | 5 | 8.5 | Below Viaduct | | | | |
| 166 | 54.380 | MDR | F | 3.2 | 6.7 | 5 | 8.5 | 1x10x5.5 (RC Box) | | 21 | | 3.47 |
| 167 | 55.828 | MDR | F | 3.3 | 9.39 | 0 | 13 | 12x30PSC Gr+150x2 RE approach | 655 | | | |
| 168 | 56.270 | ODR | F | 4.3 | 5.1 | 20 | 8.5 | 1x5.15x4.5 RC Box | | 23 | | 0.85 |
| 169 | 56.948 | Village Rd | F | 2.7 | 4.3 | 45 | 8.5 | 1x5.15x3.6 RC Box | | 34 | | 1.6 |
| 170 | 57.025 | Village Rd | F | 3 | 4.3 | 45 | 7.5 | 1x5.15x3.6 RC Box | | 34 | | 1.3 |
| 171 | 57.712 | Kutcha Rd | F | 2 | 3 | 34 | 5.5 | 1x4x2.5 (RC Box) | | 27 | | 1 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 172 | 57.784 | Kutcha Rd | F | 0.4 | 3 | 30 | 3 | 1x4x2.5 (RC Box) | | 26 | | 2.6 |
| 173 | 57.916 | Village Rd | F | 1.9 | 4.3 | 45 | 5 | 1x5.15x3.6 RC Box | | 34 | | 2.45 |
| 174 | 58.200 | Village Rd | F | 0.1 | 4.3 | 0 | 7 | 1x5.15x3.6 RC Box | | 20 | | 4.2 |
| 175 | 58.975 | Village Rd | F | 2 | 4.3 | 0 | 5.5 | 1x5.15x3.6 RC Box | | 20 | | 2.3 |
| 176 | 59.255 | Kutcha Rd | F | 0.5 | 4.3 | 45 | 2 | 1x4x2.5 (RC Box) | | 33 | | 3.8 |
| 177 | 59.293 | Village Rd | F | 0.7 | 4.3 | 14 | 6 | 1x5.15x3.6 RC Box | | 22 | | 3.6 |
| 178 | 59.672 | Village Rd | F | 0 | 4.3 | 40 | 3 | 1x5.15x3.6 RC Box | | 31 | | 4.27 |
| 179 | 59.765 | ODR | C | 3.6 | 8.4 | 3 | 8.5 | Mini ROB 1x12x7.5 RC box | 6.7 | | | |
| 180 | 59.851 | Village Rd | C | 0.9 | 8.4 | 14 | 3.5 | Mini ROB 1x12x7.5 RC box | 9.5 | | | |
| 181 | 60.589 | MDR | F | 6.6 | 6.7 | 0 | 7.7 | 1x10x5.5 (RC Box) | | 20 | | |
| 182 | 60.987 | Village Rd | F | 7.1 | 4.3 | 0 | 4.5 | 1x5.15x3.6 m RC box | | 20 | 2.8 | |
| 183 | 61.694 | Village Rd | F | 2.4 | 4.3 | 10 | 3.5 | 1x5.15x3.6 m RC box | | 20 | | 1.92 |
| 184 | 61.790 | Kucha Rd | F | 6 | 4.3 | 0 | 1.6 | 1x5.15x3.6 m RC box | | 20 | 1.65 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 185 | 61.823 | Village Rd | F | 5.3 | 4.3 | 0 | 3.5 | 1x5.15x3.6 m RC box | | 20 | 1.01 | |
| 186 | 61.919 | Village Rd | F | 3.5 | 4.3 | 15 | 4.8 | 1x5.15x3.6 m RC box | | 20 | | 0.82 |
| 187 | 62.165 | Kutcha Rd | F | 3.9 | 3 | 15 | 3 | 1x4x2.5m RC box | | 20 | 0.89 | |
| 188 | 62.529 | MDR | F | 5.3 | 6.7 | 25 | 7.6 | 1x10x5.5 (RC Box) | | 20 | | 1.38 |
| 189 | 62.970 | NH | C | 8.2 | 8.4 | 35 | 10 | Mini ROB 1x12x7.5 RC box | 24 | | | |
| 190 | 63.343 | Kutcha Rd | C | 19 | 8.4 | 25 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 191 | 63.421 | Village Rd | C | 19 | 8.4 | 0 | 4.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 192 | 63.875 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 193 | 64.027 | Kutcha Rd | F | 3.2 | 4.7 | | | Below Viaduct | | | | 1.5 |
| 194 | 64.134 | Village Rd | F | 8.3 | 5.8 | | | Below Viaduct | | | | |
| 195 | 64.366 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 196 | 64.477 | Kutcha Rd | F | 3.9 | 4.7 | | | Below Viaduct | | | | 0.85 |
| 197 | 64.600 | Village Rd | C | 5.2 | 8.4 | 35 | 4.5 | Mini ROB 1x12x7.5 RC box | 17 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 198 | 64.725 | Village Rd | C | 10 | 8.4 | 20 | 5.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 199 | 64.825 | Kutcha Rd | C | 6.9 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 200 | 64.941 | MDR | C | 8.8 | 8.4 | 15 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 201 | 65.391 | Kutcha Rd | C | 15 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 202 | 65.496 | Village Rd | C | 4 | 8.4 | 25 | 4.8 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 203 | 66.628 | Village Rd | F | 8.3 | 4.3 | 20 | 4.8 | 1x5.15x3.6 m RC box | | 20 | 3.98 | |
| 204 | 65.822 | Village Rd | F | 19 | 5.8 | | | Below Viaduct | | | | |
| 205 | 65.941 | Village Rd | F | 24 | 5.8 | | | Below Viaduct | | | | |
| 206 | 66.015 | Kutcha Rd | F | 20 | 4.7 | | | Below Viaduct | | | | |
| 207 | 66.139 | Village Rd | F | 7.2 | 5.8 | | | Below Viaduct | | | | |
| 208 | 66.357 | Village Rd | F | 14 | 5.8 | | | Below Viaduct | | | | |
| 209 | 66.558 | ODR | C | 1.5 | 8.4 | 0 | 5.9 | Mini ROB 1x12x7.5 RC box | 6 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 210 | 66.646 | Village Rd | F | 2.1 | 3 | | | 1x4x2.5m RC box | | 20 | | 0.89 |
| 211 | 66.700 | ODR | F | 4.3 | 4.3 | 15 | 7.2 | 1x5.15x3.6 m RC box | | 22 | 0 | |
| 212 | 66.783 | Village Rd | F | 2.6 | 4.3 | 15 | 3.7 | 1x5.15x3.6 m RC box | | 22 | | 1.68 |
| 213 | 66.900 | Village Rd | F | 19 | 5.8 | | | Below Viaduct | | | | |
| 214 | 67.061 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 215 | 67.800 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 216 | 67.842 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 217 | 67.921 | Kutcha Rd | F | 6.9 | 4.7 | | | Below Viaduct | | | | |
| 218 | 67.966 | Village Rd | C | 2.6 | 8.4 | 10 | 2 | Mini ROB 1x12x7.5 RC box | 13 | | | |
| 219 | 68.068 | Kutcha Rd | F | 3.7 | 3 | | | 1x4x2.5m RC box | | 20 | 0.7 | |
| 220 | 68.546 | Village Rd | C | 19 | 8.4 | 50 | 6.1 | CT&CR 1x13.25x7.5 RC box | | | | |
| 221 | 69.300 | Village Rd | C | 14 | 8.4 | 0 | 5.1 | CT&CR 1x13.25x7.5 RC box | | | | |
| 222 | 70.002 | MDR | C | 13 | 8.4 | 15 | 7.3 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 223 | 70.274 | Kutcha Rd | C | 16 | 8.4 | 40 | 2.4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 224 | 70.705 | Village Rd | F | 10 | 5.8 | | | Below Viaduct | | | | |
| 225 | 71.156 | Village Rd | F | 8.6 | 5.8 | | | Below Viaduct | | | | |
| 226 | 71.432 | Kutcha Rd | F | 8.7 | 4.7 | | | Below Viaduct | | | | |
| 227 | 71.921 | Village Rd | C | 3.1 | 8.4 | 0 | 4.4 | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 228 | 72.326 | Village Rd | C | 10 | 8.4 | 10 | 4.4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 229 | 72.538 | Kutcha Rd | C | 8.4 | 8.4 | 30 | 2 | CT&CR 1x13.25x7.5 RC box | | | | |
| 230 | 73.451 | Village Rd | C | 6 | 8.4 | 10 | 3.9 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 231 | 73.633 | Kutcha Rd | F | 3.8 | 3 | 55 | 4.6 | 1x4x2.5m RC box | | 32 | 0.83 | |
| 232 | 73.726 | ODR | C | 5.4 | 8.4 | 30 | 7.5 | Mini ROB 1x12x7.5 RC box | 28 | | | |
| 233 | 74.446 | Kutcha Rd | C | 2 | 8.4 | 0 | 2.8 | Mini ROB 1x12x7.5 RC box | 15 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 234 | 74.783 | ODR | C | 1.6 | 8.4 | 15 | 9.1 | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 235 | 75.224 | Village Rd | F | 3.1 | 4.3 | 0 | 4 | 1x5.15x3.6 m RC box | | 20 | | 1.2 |
| 236 | 75.314 | Kutcha Rd | F | 4.8 | 3 | 10 | 2.6 | 1x4x2.5m RC box | | 20 | 1.8 | |
| 237 | 75.688 | Kutcha Rd | F | 6.3 | 3 | 10 | 2.8 | 1x4x2.5m RC box | | 20 | 3.26 | |
| 238 | 76.345 | ODR | F | 1.4 | 9.39 | 45 | 7.4 | 8x30PSC Gr+150x2 RE approach | 540 | | | |
| 239 | 76.629 | Kutcha Rd | F | 9.4 | 4.7 | | | Below Viaduct | | | | |
| 240 | 77.019 | NH | C | 0.5 | 9.39 | 35 | 9.9 | 9x30PSC Gr+240x2 RE approach | 750 | | | |
| 241 | 77.283 | Kutcha Rd | C | 6.1 | 8.4 | 10 | 1.9 | Mini ROB 1x12x7.5 RC box | 11 | | | |
| 242 | 77.594 | Kutcha Rd | F | 8 | 3 | 50 | 2.7 | 1X4X2.5RC BOX | | 37 | 5 | |
| 243 | 77.646 | Kutcha Rd | F | 7.8 | 3 | | | 1X4X2.5RC BOX | | 20 | 4.82 | |
| 244 | 78.272 | Village Rd | F | 7.4 | 4.3 | 60 | 5 | 1x5.15x3.6 m RC box | | 53 | 3.1 | |
| 245 | 78.460 | Village Rd | F | 10 | 5.8 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 246 | 79.039 | Village Rd | C | 6.5 | 8.4 | 25 | 5 | Mini ROB 1x12x7.5 RC box | 9 | | | |
| 247 | 79.420 | Village Rd | C | 12 | 8.4 | 0 | 4.3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 248 | 79.577 | Village Rd | C | 7.2 | 8.4 | 30 | 5 | Mini ROB 1x12x7.5 RC box | 37 | | | |
| 249 | 79.704 | Village Rd | C | 12 | 8.4 | 30 | 5.4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 250 | 80.060 | Kutcha Rd | C | 7.9 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 251 | 80.353 | Village Rd | F | 14 | 5.8 | | | Below Viaduct | | | | |
| 252 | 80.727 | Village Rd | F | 6.4 | 4.3 | 40 | 4.8 | 1x5.15x3.6 RC Box | | 32 | 2.13 | |
| 253 | 80.945 | Kutcha Rd | F | 3.1 | 3 | 30 | 1.8 | 1x4x2.5 (RC Box) | | 28 | 0.11 | |
| 254 | 81.049 | Village Rd | C | 4.1 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 255 | 81.662 | Kutcha Rd | C | 11 | 8.4 | 60 | 5.4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 256 | 81.852 | ODR | C | 3.2 | 8.4 | 0 | 5.2 | Mini ROB 1x12x7.5 RC box | 9 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 257 | 82.155 | Village Rd | C | 0.4 | 4.3 | 30 | 4 | 1x5.15x3.6 RC Box | | 12 | | 4.67 |
| 258 | 82.475 | Village Rd | F | 5.6 | 4.3 | 0 | 4.7 | 1x5.15x3.6 RC Box | | 23 | 1.28 | |
| 259 | 82.624 | Village Rd | F | 5.5 | 4.3 | 25 | 3.9 | 1x5.15x3.6 RC Box | | 25 | 1.2 | |
| 260 | 82.877 | ODR | F | 6.7 | 5.2 | 40 | 6.4 | 1x5.15x4.5 RC Box | | 34 | 1.5 | |
| 261 | 83.631 | Kutcha Rd | C | 1 | 8.4 | 90 | 2.8 | Mini ROB 1x12x7.5 RC box | 9 | | | |
| 262 | 83.824 | Kutcha Rd | C | 14 | 8.4 | 20 | 2.9 | CT&CR 1x13.25x7.5 RC box | | | | |
| 263 | 84.260 | ODR | F | 0.3 | 8.4 | 15 | 7.4 | Mini ROB 1x12x7.5 RC box | 14 | | | |
| 264 | 84.461 | Village Rd | C | 2.5 | 8.4 | 60 | 6 | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 265 | 84.605 | Village Rd | C | 2 | 8.4 | 50 | 4.6 | Mini ROB 1x12x7.5 RC box | 26 | | | |
| 266 | 84.771 | Village Rd | F | 4.5 | 4.3 | 40 | 4.2 | 1x5.15x3.6 RC Box | | 30 | 0.2 | |
| 267 | 85.226 | Village Rd | C | 1.9 | 8.4 | 35 | | Mini ROB 1x12x7.5 RC box | 33 | | | |
| 268 | 85.650 | ODR | F | 2 | 4.3 | 57 | 7.3 | 1x5.15x3.6 RC Box | | 55 | | 2.3 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW (m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 269 | 85.995 | Kutcha Rd | F | 1.8 | 3 | 43 | 3 | 1x4x2.5 (RC Box) | | 35 | | 1.2 |
| 270 | 86.170 | Kutcha Rd | F | 7 | 3 | 66 | | 1x4x2.5 (RC Box) | | 56 | 3.95 | |
| 271 | 86.537 | ODR | C | 0 | 8.4 | 50 | 7.3 | Mini ROB 1x12x7.5 RC box | 33 | | | |
| 272 | 87.100 | Village Rd | C | 3.5 | 8.4 | 30 | 5.5 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 273 | 87.218 | Village Rd | C | 0.4 | 8.4 | 64 | 5.6 | Mini ROB 1x12x7.5 RC box | 85 | | | |
| 274 | 87.410 | Kutcha Rd | F | 2.2 | 3 | 43 | 3.4 | 1x4x2.5 (RC Box) | | 33 | | 0.78 |
| 275 | 87.567 | Kutcha Rd | C | 3.8 | 8.4 | 40 | 3.1 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 276 | 88.231 | SH | C | 7.2 | 8.4 | 20 | 11 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 277 | 88.420 | Kutcha Rd | C | 13 | 8.4 | 0 | 2.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 278 | 88.596 | Village Rd | C | 4.9 | 8.4 | 5 | 4.4 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 279 | 89.014 | Kutcha Rd | F | 2.9 | 3 | 0 | 2.4 | 1x4x2.5 (RC Box) | | 22 | | 0.07 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 280 | 89.483 | Kutcha Rd | C | 3.9 | 8.4 | 20 | 3 | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 281 | 89.619 | Kutcha Rd | C | 4.9 | 8.4 | 10 | 6.1 | Mini ROB 1x12x7.5 RC box | 11 | | | |
| 282 | 90.210 | ODR | C | 6.3 | 8.4 | 14 | 6.5 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 283 | 90.420 | Kutcha Rd | C | 4.5 | 8.4 | 35 | 4 | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 284 | 90.610 | Village Rd | C | 8.4 | 8.4 | 40 | 4 | Mini ROB 1x12x7.5 RC box | 21 | | | |
| 285 | 90.790 | Village Rd | C | 6.7 | 8.4 | 0 | 4.5 | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 286 | 91.804 | Kutcha Rd | F | 9 | 4.7 | | | Below Viaduct | | | | |
| 287 | 93.823 | Village Rd | F | 8 | 5.8 | | | Below Viaduct | | | | |
| 288 | 93.945 | Village Rd | F | 7.5 | 5.8 | | | Below Viaduct | | | | |
| 289 | 94.635 | MDR | F | 3.7 | 9.39 | 0 | 9 | 11x30PSC Gr+150x2 RE approach | 630 | | | |
| 290 | 95.085 | ODR | F | 2.9 | 5.2 | 4 | 5.6 | 1x5.15x4.5 RC Box | | 23 | | 2.26 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 291 | 95.355 | Village Rd | F | 5.1 | 4.3 | 15 | 4.5 | 1x5.15x3.6 RC Box | | 23 | 0.83 | |
| 292 | 95.924 | Village Rd | F | 4.6 | 4.3 | 35 | 4.7 | 1x5.15x3.6 RC Box | | 36 | 0.33 | |
| 293 | 96.638 | Village Rd | F | 5 | 5.8 | | | Below Viaduct | | | | 0.77 |
| 294 | 97.005 | Village Rd | F | 1.2 | 8.4 | 60 | 4.1 | Mini ROB 1x12x7.5 RC box | 9 | | | |
| 295 | 97.117 | Village Rd | C | 10 | 8.4 | 0 | 3.9 | CT&CR 1x13.25x7.5 RC box | | | | |
| 296 | 97.456 | ODR | C | 8.2 | 8.4 | 49 | 7.5 | Mini ROB 1x12x7.5 RC box | 33 | | | |
| 297 | 97.585 | Kutcha Rd | C | 17 | 8.4 | 25 | 2.3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 298 | 97.610 | Kutcha Rd | C | 18 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 299 | 97.685 | Kutcha Rd | | | 8.4 | 20 | 2.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 300 | 97.761 | Kutcha Rd | | | 8.4 | 20 | 2 | CT&CR 1x13.25x7.5 RC box | | | | |
| 301 | 98.048 | Village Rd | | | 8.4 | 60 | 5.2 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 302 | 98.340 | Kutcha Rd | | | 8.4 | 30 | 2.6 | CT&CR 1x13.25x7.5 RC box | | | | |
| 303 | 98.445 | ODR | | | 8.4 | 40 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 304 | 98.531 | Kutcha Rd | | | 8.4 | 50 | 1.8 | CT&CR 1x13.25x7.5 RC box | | | | |
| 305 | 98.947 | ODR | | | 8.4 | 70 | 7.2 | CT&CR 1x13.25x7.5 RC box | | | | |
| 306 | 99.006 | Kutcha Rd | | | 8.4 | 0 | 3.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 307 | 99.074 | Village Rd | | | 8.4 | 15 | 4.6 | CT&CR 1x13.25x7.5 RC box | | | | |
| 308 | 99.553 | Village Rd | | | 8.4 | 15 | 4.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 309 | 100.384 | Village Rd | C | 13 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 310 | 100.513 | Village Rd | C | 1.8 | 8.4 | 39 | 7 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 311 | 102.012 | SH | F | 7.1 | 6.8 | 21 | 14 | 1x11.5x5.5 m RC box | | 35 | 0.3 | |
| 312 | 102.216 | Village Rd | F | 8.1 | 4.3 | 18 | 4 | 1x5.15x3.6 m RC box | | 27 | 3.75 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 313 | 102.328 | Village Rd | F | 3.2 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 1.1 |
| 314 | 102.406 | Village Rd | F | 0.2 | 8.4 | 30 | 3.5 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 315 | 103.043 | Village Rd | F | 0.9 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 316 | 103.154 | Kutcha Rd | C | 6.5 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 50 | | | |
| 317 | 104.425 | ODR | F | 4.8 | 4.3 | | | 1x5.15x4.5 m Rcbox | | 35 | 0.5 | |
| 318 | 105.144 | Village Rd | F | 4.2 | 4.3 | 5 | | 1x5.15x3.6 m Rcbox | | 25 | | 0.07 |
| 319 | 105.362 | SH | F | 2.8 | 9.39 | 0 | | 12x30PSC Gr+150x2 RE approach | 640 | | | |
| 320 | 105.461 | Kutcha Rd | F | 2.1 | 3 | 0 | | 1x4x2.5m RC box | | 20 | | 0.9 |
| 321 | 105.947 | Village Rd | F | 2.6 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 22 | | 1.7 |
| 322 | 106.214 | Village Rd | F | 4.6 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 30 | 0.3 | |
| 323 | 106.374 | Village Rd | F | 4.5 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 25 | 0.23 | |
| 324 | 106.952 | Kutcha Rd | F | 5.3 | 3 | 33 | | 1x4x2.5m RC box | | 29 | 2.3 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 325 | 107.257 | Village Rd | F | 6.7 | 4.3 | 70 | | 1x5.15x3.6 m RC box | | 90 | 2.4 | |
| 326 | 107.895 | ODR | C | 3.8 | 8.4 | 30 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 327 | 108.391 | Village Rd | F | 3.7 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 0.6 |
| 328 | 108.730 | Village Rd | F | 0 | 8.4 | 50 | | Mini ROB 1x12x7.5 RC box | 40 | | | |
| 329 | 109.080 | Village Rd | C | 1.6 | 8.4 | 65 | | Mini ROB 1x12x7.5 RC box | 76 | | | |
| 330 | 109.520 | Village Rd | C | 1 | 8.4 | 26 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 331 | 109.647 | Village Rd | F | 0.9 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 28 | | 3.38 |
| 332 | 109.827 | Village Rd | F | 4 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 0.3 |
| 333 | 109.978 | Kutcha Rd | F | 4.2 | 3 | 15 | | 1x4x2.5m RC box | | 25 | 1.15 | |
| 334 | 110.031 | Village Rd | F | 4.6 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 20 | 0.3 | |
| 335 | 110.100 | Village Rd | F | 3.9 | 4.3 | 26 | | 1x5.15x3.6 m RC box | | 28 | | 0.39 |
| 336 | 110.600 | Village Rd | F | 5.3 | 4.3 | 10 | | 1x5.15x3.6 m RC box | | 20 | 1.04 | |
| 337 | 110.960 | ODR | F | 5.2 | 5.2 | 49 | | 1x5.15x4.5 m RC box | | | | 0.04 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 338 | 111.446 | SH | F | 3.4 | 9.39 | 0 | | 12x30PSC Gr+150x2 RE approach | 670 | | | |
| 339 | 111.786 | Village Rd | F | 3 | 4.3 | 41 | | 1x5.15x3.6 m RC box | | 33 | | 1.28 |
| 340 | 112.133 | Village Rd | F | 2.3 | 4.3 | 28 | | 1x5.15x3.6 m RC box | | 29 | | 2 |
| 341 | 112.653 | Village Rd | F | 3.3 | 4.3 | 10 | | 1x5.15x3.6 m RC box | | 20 | | 1.05 |
| 342 | 113.067 | MDR | F | 2.1 | 6.7 | 25 | | 1x10x5.5 m (RC Box) | | 28 | | 4.62 |
| 343 | 113.779 | Village Rd | C | 2.7 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 344 | 114.710 | MDR | F | 1.7 | 9.39 | 53 | | 10x30PSC Gr+150x2 RE approach | 583 | | | |
| 345 | 115.564 | Village Rd | F | 5.6 | 4.3 | 10 | | Below Viaduct | | | | |
| 346 | 115.770 | MDR | F | 1 | 9.39 | 0 | | 9x30PSC Gr+150x2 RE approach | 550 | | | |
| 347 | 116.500 | Village Rd | F | 9.6 | 5.8 | 50 | | Below Viaduct | | | | |
| 348 | 116.669 | Village Rd | F | 12 | 5.8 | 40 | | Below Viaduct | | | | |
| 349 | 116.745 | Village Rd | F | 4.5 | 4.3 | 62 | | 1x5.15x3.6 m RC box | | 47 | 0.2 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 350 | 117.222 | MDR | C | 2.9 | 8.4 | 63 | | Mini ROB 1x12x7.5 RC box | 65 | | | |
| 351 | 117.507 | Village Rd | C | 0.5 | 8.4 | 60 | | Mini ROB 1x12x7.5 RC box | 45 | | | |
| 352 | 118.100 | Village Rd | F | 14 | 5.8 | 25 | | Below Viaduct | | | | |
| 353 | 118.243 | Village Rd | F | 3.5 | 4.3 | 15 | | 1x5.15x3.6 m RC box | | 25 | | 0.85 |
| 354 | 118.540 | ODR | C | 0.4 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 355 | 118.700 | Village Rd | F | 10 | 5.8 | 0 | | Below Viaduct | | | | |
| 356 | 118.800 | Village Rd | C | 3 | 8.4 | 30 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 357 | 118.910 | Village Rd | C | 9.9 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 358 | 119.245 | Village Rd | F | 3.8 | 5.8 | 10 | | Below Viaduct | | | | |
| 359 | 119.400 | Village Rd | C | 3.4 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 360 | 119.945 | Village Rd | F | 15 | 5.8 | 60 | | Below Viaduct | | | | |
| 361 | 120.400 | Village Rd | C | 14 | 8.4 | 55 | | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 362 | 120.500 | Village Rd | C | 3.9 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 363 | 120.968 | Village Rd | F | 2 | 4.3 | 0 | | 1x4x2.5m RC box | | 20 | | 2.3 |
| 364 | 121.466 | Village Rd | F | 1.3 | 4.3 | 30 | | 1X5.15X3.6 RC Box | | 25 | | 3.02 |
| 365 | 121.660 | Village Rd | C | 0.6 | 8.4 | 50 | | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 366 | 121.753 | Village Rd | F | 4.6 | 5.8 | 15 | | Below Viaduct | | | | |
| 367 | 122.000 | Village Rd | F | 5.5 | 4.3 | 40 | | 1X5.15X3.6 RC Box | | 30 | 1.18 | |
| 368 | 122.182 | Village Rd | F | 18 | 5.8 | 35 | | Below Viaduct | | | | |
| 369 | 122.700 | Village Rd | F | 17 | 5.8 | 45 | | Below Viaduct | | | | |
| 370 | 122.880 | Village Rd | F | 3 | 4.3 | 45 | 4 | 1X5.15X3.6 RC Box | | 35 | | 1.3 |
| 371 | 123.147 | Village Rd | F | 2.7 | 9.39 | 45 | | 14x30PSC Gr+120x2 RE approach | 514 | | | |
| 372 | 123.456 | Village Rd | F | 6 | 4.3 | 35 | | 1X5.15X3.6 RC Box | | 30 | 1.7 | |
| 373 | 123.960 | Village Rd | F | 13 | 5.8 | 35 | | Below Viaduct | | | | |
| 374 | 124.000 | Kutcha Rd | F | 9.6 | 5.8 | 55 | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 375 | 124.495 | Village Rd | F | 1.6 | 4.3 | 45 | | 1X5.15X3.6 RC Box | | 30 | | 2.7 |
| 376 | 124.652 | MDR | F | 13 | 7.7 | 40 | | Below Viaduct | | | | |
| 377 | 125.045 | MDR | F | 6 | 6.7 | 45 | | 1x10x5.5 m (RC Box) | | 35 | | 0.74 |
| 378 | 125.710 | Village Rd | C | 7,5 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 379 | 125.980 | Village Rd | F | 8.3 | 4.3 | 0 | | 1X5.15X3.6 RC Box | | 20 | 4.21 | |
| 380 | 126.320 | MDR | F | 9.5 | 7.7 | | | Below Viaduct | | | | |
| 381 | 126.800 | ODR | F | 4.8 | 5.2 | 45 | | 1X5.15X4.5 RC Box | | 40 | | 0.44 |
| 382 | 127.510 | MDR | C | 0.5 | 8.4 | 20 | | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 383 | 128.000 | Village Rd | C | 3.1 | 8.4 | 25 | | Mini ROB 1x12x7.5 RC box | 13 | | | |
| 384 | 128.330 | Village Rd | C | 3.1 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 385 | 128.710 | Village Rd | C | 4 | 8.4 | 20 | | Mini ROB 1x12x7.5 RC box | 11 | | | |
| 386 | 128.850 | Village Rd | C | 5.8 | 8.4 | 10 | | Mini ROB 1x12x7.5 RC box | 8.4 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 387 | 129.610 | MDR | F | 1.3 | 9.39 | 35 | | 9x30PSC Gr+150x2 RE approach | 562 | | | |
| 388 | 130.618 | Village Rd | C | 3.8 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 389 | 131.907 | MDR | F | 3.7 | 9.39 | 45 | | 13x30PSC Gr+150x2 RE approach | 683 | | | |
| 390 | 132.943 | MDR | F | 4.2 | 6.7 | 50 | | 1x10x5.5 m (RC Box) | | 45 | | 2.55 |
| 391 | 133.110 | MDR | C | 6.2 | 8.4 | 37 | | Mini ROB 1x12x7.5 RC box | 26 | | | |
| 392 | 133.170 | Kucha Rd | C | 9.8 | 8.4 | 25 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 393 | 133.400 | Village Rd | C | 6.1 | 8.4 | 40 | | Mini ROB 1x12x7.5 RC box | 28 | | | |
| 394 | 133.595 | MDR | F | 2.2 | 6.7 | 0 | | 1x10x5.5 m (RC Box) | | 20 | | 4.49 |
| 395 | 133.880 | Village Rd | C | 7.2 | 8.4 | 10 | | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 396 | 133.950 | ODR | C | 14 | 8.4 | 55 | | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 397 | 134.230 | MDR | C | 11 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 398 | 135.035 | MDR | F | 9.6 | 5.8 | 0 | | Below Viaduct | | | | |
| 399 | 135.412 | Village Rd | F | 9.4 | 5.8 | 0 | | Below Viaduct | | | | |
| 400 | 136.500 | Village Rd | F | 7.1 | 5.8 | 65 | | Below Viaduct | | | | |
| 401 | 136.590 | Village Rd | F | 2.2 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 2.1 |
| 402 | 136.665 | Village Rd | C | 4.5 | 8.4 | 55 | | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 403 | 136.740 | Village Rd | C | 11 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 404 | 136.920 | Village Rd | F | 6.8 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 25 | 2.51 | |
| 405 | 137.115 | Village Rd | F | 3.9 | 9.39 | | | 12x30PSC Gr+150x2 RE approach | 592 | | | |
| 406 | 137.515 | SH | C | 17 | 8.4 | 10 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 407 | 137.695 | Village Rd | F | 0.5 | 8.4 | 5 | | Mini ROB 1x12x7.5 RC box | 7.2 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 408 | 137.733 | Village Rd | C | 4.6 | 4.3 | | | Mini ROB 1x12x7.5 RC box | 7 | | | |
| 409 | 137.780 | MDR | C | 12 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 410 | 137.828 | Village Rd | C | 15 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 411 | 137.844 | Village Rd | C | 15 | 8.4 | 5 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 412 | 137.980 | Kutcha Rd | F | 3.7 | 3 | 50 | | 1x4x2.5 m RC Box | | 37 | 0.7 | |
| 413 | 138.220 | Kutcha Rd | C | 11 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 414 | 138.400 | MDR | F | 2.1 | 9.39 | 70 | | 11x30PSC Gr+150x2 RE approach | 635 | | | |
| 415 | 138.510 | Village Rd | F | 4.1 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 35 | | 0.18 |
| 416 | 138.985 | Village Rd | F | 2.3 | 9.39 | 30 | | 9x30PSC Gr+120x2 RE approach | 496 | | | |
| 417 | 139.173 | MDR | F | 1.9 | 9.39 | 20 | | 10x30PSC Gr+150x2 RE approach | 595 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&C over | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 418 | 139.622 | Kutcha Rd | F | 3.5 | 3 | 45 | | 1x4x2.5 m RC Box | | 33 | 0.5 | |
| 419 | 139.662 | Kutcha Rd | F | 3.2 | 3 | 50 | | 1x4x2.5 m RC Box | | 37 | 0.2 | |
| 420 | 139.740 | Village Rd | F | 3.2 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 34 | | 1.1 |
| 421 | 139.780 | Village Rd | F | 3.6 | 4.3 | 50 | | 1x5.15x3.6 m RC box | | 38 | | 0.7 |
| 422 | 139.907 | Village Rd | F | 2.9 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 1.4 |
| 423 | 139.965 | Village Rd | F | 3.5 | 4.3 | 5 | | 1x5.15x3.6 m RC box | | 21 | | 0.77 |
| 424 | 140.000 | Village Rd | F | 3.6 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 25 | | 0.7 |
| 425 | 140.040 | Village Rd | F | 3.6 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 25 | | 0.7 |
| 426 | 140.415 | MDR | C | 0.5 | 8.4 | 10 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 427 | 140.543 | Kutcha Rd | C | 22 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 428 | 140.588 | Kutcha Rd | C | 27 | 8.4 | 50 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 429 | 140.722 | Village Rd | C | 8.7 | 8.4 | 45 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 430 | 140.878 | Village Rd | F | 5 | 5.8 | 60 | | Below Viaduct | | | | 0.8 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 431 | 140.895 | Village Rd | F | 6.3 | 5.8 | 35 | | Below Viaduct | | | | |
| 432 | 141.390 | Village Rd | F | 5.5 | 6.7 | 30 | | 1X10X5.5m RC Box | | | | 1.2 |
| 433 | 141.868 | Village Rd | C | 6.5 | 8.4 | 42 | 5 | Mini ROB 1x12x7.5 RC box | 28 | | | |
| 434 | 141.922 | Village Rd | C | 5 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 435 | 142.085 | Village Rd | F | 10 | 5.8 | 30 | | Below Viaduct | | | | |
| 436 | 142.487 | MDR | F | 13 | 7.7 | 60 | | Below Viaduct | | | | |
| 437 | 142.809 | Kutcha Rd | F | 13 | 4.7 | 0 | | Below Viaduct | | | | |
| 438 | 142.905 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 439 | 142.973 | Kutcha Rd | F | 13 | 4.7 | 0 | | Below Viaduct | | | | |
| 440 | 143.100 | Kutcha Rd | F | 14 | 4.7 | 30 | | Below Viaduct | | | | |
| 441 | 143.242 | Village Rd | F | 14 | 5.8 | 65 | | Below Viaduct | | | | |
| 442 | 143.318 | Village Rd | F | 14 | 5.8 | 15 | | Below Viaduct | | | | |
| 443 | 144.050 | Village Rd | F | 7.6 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 27 | 3.3 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 444 | 144.090 | MDR | F | 7 | 6.7 | 45 | | 1X10X5.5m RC Box | | 40 | 0.3 | |
| 445 | 144.167 | Kutcha Rd | F | 7 | 3 | 45 | | 1x4x2.5m RC box | | 35 | 4 | |
| 446 | 144.340 | Village Rd | F | 5 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 25 | 0.7 | |
| 447 | 144.695 | ODR | F | 8 | 5.2 | 0 | | 1x5.15x4.5 m RC box | | 20 | 2.8 | |
| 448 | 144.752 | Village Rd | F | 3.5 | 4.3 | 10 | | 1x5.15x3.6 m RC box | | 21 | | 0.8 |
| 449 | 145.010 | Village Rd | F | 6.3 | 4.3 | 5 | | 1x5.15x3.6 m RC box | | 21 | 2 | |
| 450 | 145.176 | MDR | F | 3 | 6.7 | 10 | | 1X10X5.5m RC Box | | 21 | | 3.7 |
| 451 | 145.663 | Village Rd | F | 6.1 | 5.8 | 45 | | Below Viaduct | | | | |
| 452 | 145.756 | Village Rd | F | 9 | 5.8 | 45 | | Below Viaduct | | | | |
| 453 | 145.960 | Kutcha Rd | F | 1.4 | 3 | 0 | | 1x4x2.5m RC box | | 25 | | 1.6 |
| 454 | 146.034 | Village Rd | C | 1.2 | 8.4 | 30 | | Mini ROB 1x12x7.5 RC box | 19 | | | |
| 455 | 146.352 | Kutcha Rd | F | 9.4 | 4.7 | 45 | | Below Viaduct | | | | |
| 456 | 147.000 | MDR | F | 8.6 | 7.7 | 30 | | Below Viaduct | | | | |
| 457 | 147.073 | Village Rd | F | 11 | 5.8 | 0 | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 458 | 147.558 | SH | F | 12 | 7.7 | 45 | | Below Viaduct | | | | |
| 459 | 147.817 | Village Rd | C | 0 | 8.4 | 5 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 460 | 148.067 | Village Rd | F | 0.8 | 8.4 | 15 | | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 461 | 148.267 | Village Rd | C | 7.7 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 13 | | | |
| 462 | 148.600 | Village Rd | C | 0.4 | 8.4 | 50 | | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 463 | 148.800 | Village Rd | F | 1.2 | 9.39 | 40 | | 7x30PSC Gr+120x2 RE approach | 452 | | | |
| 464 | 148.900 | Village Rd | C | 8.7 | 8.4 | 75 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 465 | 149.100 | Village Rd | C | 0.2 | 8.4 | 70 | | Mini ROB 1x12x7.5 RC box | 57 | | | |
| 466 | 149.300 | Kutcha Rd | C | 0.4 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 467 | 149.700 | Village Rd | C | 0.9 | 8.4 | 10 | | Mini ROB 1x12x7.5 RC box | 12 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 468 | 150.435 | Village Rd | C | 22 | 8.4 | 30 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 469 | 150.835 | Village Rd | F | 3.3 | 4.3 | 42 | 4 | 1x5.15x3.6 m RC box | | 30 | | 0.98 |
| 470 | 151.100 | Village Rd | F | 5.6 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | 1.3 | |
| 471 | 151.217 | Village Rd | F | 7.8 | 4.3 | 22 | | 1x5.15x3.6 m RC box | | 30 | 3.53 | |
| 472 | 151.449 | Village Rd | C | 16 | 8.4 | 25 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 473 | 151.785 | Kutcha Rd | F | 11 | 4.7 | 10 | | Below Viaduct | | | | |
| 474 | 152.300 | MDR | F | 8.6 | 7.7 | 30 | | Below Viaduct | | | | |
| 475 | 152.524 | MDR | C | 0.2 | 8.4 | 20 | 15 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 476 | 153.023 | Village Rd | F | 2.3 | 9.39 | 15 | | 9x30PSC Gr+120x2 RE approach | 498 | | | |
| 477 | 153.633 | MDR | C | 5.5 | 8.4 | 45 | 8 | Mini ROB 1x12x7.5 RC box | 32 | | | |
| 478 | 154.014 | Village Rd | F | 7.5 | 5.8 | 10 | | Below Viaduct | | | | |
| 479 | 154.307 | Village Rd | F | 6 | 4.3 | 45 | | 1x5.15x3.6 m Rcbox | | 35 | 1.7 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 480 | 154.750 | Village Rd | F | 4.5 | 4.3 | 45 | | 1x5.15x3.6 m Rcbox | | 35 | 0.2 | |
| 481 | 155.560 | Village Rd | C | 6.9 | 8.4 | 60 | 4 | Mini ROB 1x12x7.5 RC box | 35 | | | |
| 482 | 155.684 | Village Rd | C | 6.8 | 8.4 | 60 | | Mini ROB 1x12x7.5 RC box | 35 | | | |
| 483 | 155.835 | Village Rd | C | 8.6 | 8.4 | 20 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 484 | 156.180 | Village Rd | C | 5 | 8.4 | 30 | 5 | Mini ROB 1x12x7.5 RC box | 17 | | | |
| 485 | 157.040 | MDR | C | 1 | 8.4 | 31 | 7.5 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 486 | 157.501 | Kutcha Rd | F | 13 | 4.7 | 65 | | Below Viaduct | | | | |
| 487 | 157.750 | MDR | F | 6.6 | 7.7 | 54 | | Below Viaduct | | | | |
| 488 | 157.942 | Village Rd | C | 9.6 | 8.4 | 60 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 489 | 158.149 | Kutcha Rd | C | 24 | 8.4 | 60 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 490 | 158.243 | Kutcha Rd | C | 22 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 491 | 158.945 | Village Rd | F | 2.5 | 9.39 | 30 | | 9x30PSC Gr+120x2 RE approach | 506 | | | |
| 492 | 159.025 | Village Rd | F | 1 | 9.39 | | | 7x30PSC Gr+120x2 RE approach | 446 | | | |
| 493 | 159.656 | ODR | F | 2.5 | 9.39 | 0 | | 9x30PSC Gr+120x2 RE approach | 506 | | | |
| 494 | 160.104 | Kutcha Rd | F | 0.2 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 495 | 160.196 | Village Rd | C | 12 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 496 | 161.028 | MDR | C | 3 | 8.4 | 30 | | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 497 | 161.530 | Village Rd | F | 3.2 | 9.39 | 50 | | 11x30PSC Gr+120x2 RE approach | 564 | | | |
| 498 | 161.616 | Village Rd | F | 4.7 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 27 | | |
| 499 | 161.824 | MDR | F | 0.4 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 12 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW (m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 500 | 162.077 | Village Rd | C | 2 | 8.4 | 25 | | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 501 | 162.316 | Village Rd | F | 4.3 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 31 | 0 | |
| 502 | 162.332 | Kutcha Rd | F | 3.7 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.7 | |
| 503 | 162.570 | Kutcha Rd | C | 9.1 | 8.4 | 65 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 504 | 162.595 | Kutcha Rd | C | 9.3 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 505 | 162.610 | Kutcha Rd | C | 9.3 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 506 | 162.706 | Kutcha Rd | C | 6.2 | 8.4 | 15 | | Mini ROB 1x12x7.5 RC box | 8.6 | | | |
| 507 | 162.755 | Kutcha Rd | C | 5.3 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 508 | 162.900 | Kutcha Rd | F | 6.5 | 3 | 25 | | 1x4x2.5m RC box | | 25 | 3.5 | |
| 509 | 162.934 | Kutcha Rd | F | 8 | 3 | | | 1x4x2.5m RC box | | 20 | 5 | |
| 510 | 163.092 | Kutcha Rd | F | 9.8 | 4.7 | 90 | | Below Viaduct | | | | |
| 511 | 163.341 | Village Rd | F | 5.5 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 23 | 1.2 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 512 | 163.792 | Kutcha Rd | C | 4.1 | 3 | 20 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 513 | 163.963 | MDR | C | 9.5 | 8.4 | 20 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 514 | 164.566 | Village Rd | C | 14 | 8.4 | 40 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 515 | 165.005 | Kutcha Rd | F | 14 | 4.7 | 40 | | Below Viaduct | | | | |
| 516 | 165.328 | MDR | F | 4.5 | 6.7 | 0 | | 1x10x5.5 m RC Box | | 20 | | 2.2 |
| 517 | 165.425 | MDR | F | 5.5 | 6.7 | 60 | | 1x10x5.5 m RC Box | | 61 | | 12.2 |
| 518 | 165.673 | MDR | F | 3.8 | 9.39 | 30 | | 13x30PSC Gr+150x2 RE approach | 690 | | | |
| 519 | 165.965 | Kutcha Rd | F | 6.8 | 4.7 | | | Below Viaduct | | | | |
| 520 | 165.993 | MDR | F | 6.5 | 7.7 | 30 | | Below Viaduct | | | | |
| 521 | 166.981 | MDR | C | 0 | 8.4 | 35 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 522 | 168.662 | Kutcha Rd | F | 4.6 | 4.7 | 40 | | Below Viaduct | | | | |
| 523 | 168.871 | Village Rd | F | 3.2 | 4.3 | 45 | | 1x5.15x3.6 m Rc box | | 34 | | 1.1 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW (m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 524 | 169.013 | MDR | F | 2.4 | 9.39 | 25 | | 11x30PSC Gr+150x2 RE approach | 620 | | | |
| 525 | 169.319 | Village Rd | F | 2.1 | 4.3 | 10 | | 1x5.15x3.6 m Rc box | | | | 2.2 |
| 526 | 169.883 | MDR | F | 5.6 | 7.7 | 45 | | 1x10x5.5 m RC box | | | | 2.1 |
| 527 | 170.069 | Village Rd | F | 2.6 | 4.3 | 70 | | 1x5.15x3.6 m Rc box | | 75 | | 1.74 |
| 528 | 170.760 | Village Rd | C | 7.3 | 8.4 | 20 | | Mini ROB 1x12x7.5 RC box | 10 | | | |
| 529 | 171.490 | MDR | F | 1.3 | 9.39 | 10 | | 9x30PSC Gr+150x2 RE approach | 565 | | | |
| 530 | 171.940 | Village Rd | F | 3.1 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 27 | | 1.2 |
| 531 | 172.980 | Kutcha Rd | F | 2.5 | 3 | 30 | | 1x4x2.5 m RC box | | 26 | | 0.5 |
| 532 | 173.250 | Village Rd | C | 7 | 8.4 | 65 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 533 | 174.077 | MDR | F | 0.1 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 57 | | | |
| 534 | 174.194 | Village Rd | C | 0.3 | 8.4 | 65 | | Mini ROB 1x12x7.5 RC box | 43 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 535 | 174.226 | Kutcha Rd | C | 3 | 8.4 | 50 | | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 536 | 174.622 | Village Rd | F | 8 | 5.8 | | | Below Viaduct | | | | |
| 537 | 174.677 | Village Rd | F | 8 | 5.8 | 10 | | Below Viaduct | | | | |
| 538 | 174.726 | Kutcha Rd | F | 8 | 4.7 | 50 | | Below Viaduct | | | | |
| 539 | 174.908 | Village Rd | F | 3.3 | 4.7 | 40 | | Below Viaduct | | | | |
| 540 | 175.692 | Kutcha Rd | C | 3.7 | 8.4 | 40 | | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 541 | 175.700 | Kutcha Rd | C | 3.7 | 8.4 | 40 | | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 542 | 175.943 | MDR | F | 1.8 | 9.39 | 55 | | 10x30PSC Gr+150x2 RE approach | 590 | | | |
| 543 | 176.134 | Kutcha Rd | C | 0.8 | 8.4 | 15 | | Mini ROB 1x12x7.5 RC box | 8.6 | | | |
| 544 | 176.229 | Kutcha Rd | C | 5.1 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 545 | 176.430 | MDR | F | 4.5 | 6.7 | 10 | | 1x10x5.5 m RC box | | 22 | | 2.24 |
| 546 | 177.347 | ODR | F | 1.3 | 5.2 | 15 | | 1x5.15x4.5 m RC box | | 22 | | 3.95 |

| S.No | Chainage | Type of Road | Filling/Cutting/C&C over | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 547 | 177.700 | Village Rd | C | 0 | 8.4 | 50 | | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 548 | 178.013 | Village Rd | F | 4 | 4.3 | 25 | | 1x5.15x3.6 m RC box | | 25 | | 0.3 |
| 549 | 178.365 | Village Rd | F | 3.5 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 0.76 |
| 550 | 178.600 | Village Rd | F | 5.6 | 4.3 | 15 | | 1x5.15x3.6 m RC box | | 22 | 1.34 | |
| 551 | 179.151 | Village Rd | F | 3.3 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 31 | | 0.98 |
| 552 | 179.612 | Village Rd | F | 2.5 | 9.39 | 10 | | 9x30PSC Gr+120x2 RE approach | 504 | | | |
| 553 | 179.746 | Kutcha Rd | C | 7.5 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 554 | 179.970 | Kutcha Rd | C | 9.7 | 8.4 | 10 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 555 | 180.130 | Village Rd | C | 10 | 8.4 | 50 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 556 | 180.311 | Village Rd | F | 0.6 | 4.3 | 70 | | 1x5.15x3.6 m RC box | | 75 | | 3.7 |
| 557 | 180.350 | Kutcha Rd | F | 4.5 | 3 | 0 | | 1x4x2.5 m RC box | | 20 | 1.45 | |
| 558 | 180.504 | Kutcha Rd | F | 10 | 4.7 | 0 | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 559 | 180.518 | Kutcha Rd | F | 9.8 | 4.7 | 0 | | Below Viaduct | | | | |
| 560 | 180.538 | Village Rd | F | 9 | 5.8 | 0 | | Below Viaduct | | | | |
| 561 | 180.788 | Kutcha Rd | C | 10 | 8.4 | 40 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 562 | 181.184 | Village Rd | C | 2.8 | 8.4 | 30 | | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 563 | 181.446 | Village Rd | F | 2.3 | 4.3 | 55 | | 1x5.15x3.6 m RC box | | 43 | | 2 |
| 564 | 181.764 | Village Rd | F | 4.9 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 31 | 0.55 | |
| 565 | 182.021 | Kutcha Rd | C | 4.6 | 8.4 | 15 | | Mini ROB 1x12x7.5 RC box | 9.8 | | | |
| 566 | 182.062 | Kutcha Rd | C | 9.7 | 8.4 | 45 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 567 | 182.200 | Kutcha Rd | C | 14 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 568 | 182.385 | Kutcha Rd | F | 3 | 3 | 50 | | 1x4x2.5 m RC box | | 37 | 0 | |
| 569 | 182.703 | Village Rd | C | 1.1 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 570 | 183.043 | Village Rd | F | 6.2 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 31 | 1.9 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 571 | 183.621 | Kutcha Rd | C | 8.5 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 572 | 183.689 | Village Rd | C | 18 | 8.4 | 45 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 573 | 183.957 | Kutcha Rd | C | 5.8 | 8.4 | 10 | | Mini ROB 1x12x7.5 RC box | 7.3 | | | |
| 574 | 184.006 | Village Rd | C | 4.3 | 8.4 | 50 | | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 575 | 185.002 | Village Rd | F | 1 | 9.39 | 45 | | 7x30PSC Gr+120x2 RE approach | 446 | | | |
| 576 | 186.122 | Kutcha Rd | F | 2.4 | 3 | | | 1x4x2.5 m Rc box | | 20 | | 0.62 |
| 577 | 186.460 | Village Rd | F | 2.3 | 4.3 | 35 | | 1x5.15x3.6 m RC box | | 29 | | 1.97 |
| 578 | 186.830 | NH | F | 2 | 9.39 | 10 | | 15x30PSC Gr+240x2 RE approach | 944 | | | |
| 579 | 186.913 | Kutcha Rd | F | 1.1 | 3 | | | 1x4x2.5 m RC box | | 20 | | 1.95 |
| 580 | 187.119 | Kutcha Rd | F | 0.7 | 3 | 15 | | 1x4x2.5 m RC box | | 22 | | 2.3 |
| 581 | 187.289 | Village Rd | F | 1.7 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 23 | | 2.64 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 582 | 187.937 | Village Rd | F | 3.8 | 4.3 | 10 | | 1x5.15x3.6 m RC box | | 21 | | 0.5 |
| 583 | 188.142 | Village Rd | F | 0.9 | 9.39 | | | 7x30PSC Gr+120x2 RE approach | 442 | | | |
| 584 | 188.280 | Kutcha Rd | F | 1.2 | 9.39 | 20 | | 7x30PSC Gr+120x2 RE approach | 454 | | | |
| 585 | 188.493 | ODR | C | 0.1 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 586 | 188.526 | Kutcha Rd | F | 3.4 | 3 | 0 | | 1x4x2.5 m RC box | | 20 | 0.4 | |
| 587 | 188.783 | Kutcha Rd | F | 2.4 | 3 | 25 | | 1x4x2.5 m RC box | | 24 | | 0.6 |
| 588 | 188.865 | Village Rd | F | 2.1 | 3 | 20 | | 1x4x2.5 m RC box | | 23 | | 0.86 |
| 589 | 188.924 | Kutcha Rd | F | 2.3 | 3 | 0 | | 1x4x2.5 m RC box | | 20 | | 0.75 |
| 590 | 189.066 | Village Rd | F | 3.9 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 31 | | 0.42 |
| 591 | 190.063 | ODR | F | 12 | 6.7 | 15 | | Below Viaduct | | | | |
| 592 | 190.907 | Kutcha Rd | F | 6.9 | 4.7 | 25 | | Below Viaduct | | | | |
| 593 | 192.700 | Village Rd | F | 3.2 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 27 | | 1.15 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 594 | 194.054 | MDR | F | 4.3 | 6.7 | 20 | | 1x10x5.5 m RC box | | 23 | | 2.45 |
| 595 | 194.854 | Kutcha Rd | F | 4.4 | 3 | | | 1x4x2.5 m RC box | | 20 | 1.38 | |
| 596 | 196.200 | Kutcha Rd | C | 3.3 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 597 | 196.355 | Village Rd | F | 1 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 23 | | 3.3 |
| 598 | 196.778 | Village Rd | C | 5 | 8.4 | 0 | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 599 | 196.873 | Kutcha Rd | C | 12 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 600 | 197.478 | SH | F | 4.1 | 9.39 | 0 | | 13x30PSC Gr+150x2 RE approach | 705 | | | |
| 601 | 198.400 | Kutcha Rd | F | 1.7 | 3 | 60 | | 1x4x2.5 m RC box | | 48 | | 1.33 |
| 602 | 198.646 | ODR | F | 2.1 | 5.2 | 10 | | 1x5.15x4.5 m RC box | | 21 | | 3.1 |
| 603 | 198.741 | Kutcha Rd | F | 1.4 | 3 | 0 | | 1x4x2.5 m RC box | | 20 | | 1.59 |
| 604 | 199.277 | Kutcha Rd | F | 2.7 | 3 | 0 | | 1x4x2.5 m RC box | | 20 | | 0.3 |
| 605 | 199.364 | Village Rd | F | 2.6 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 23 | | 1.7 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 606 | 200.285 | Village Rd | F | 3.4 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 0.89 |
| 607 | 200.383 | Village Rd | F | 7.9 | 5.8 | | | Below Viaduct | | | | |
| 608 | 200.750 | MDR | F | 7.2 | 7.7 | | | Below Viaduct | | | | |
| 609 | 200.870 | Kutcha Rd | F | 3.7 | 3 | 32 | 4.2 | 1x4x2.5 m RC box | | 27 | 0.66 | |
| 610 | 201.065 | MDR | F | 7 | 6.7 | 60 | 9.2 | 1x10x5.5 m RC box | | 61 | 0.3 | |
| 611 | 201.120 | ODR | F | 8.3 | 5.2 | 0 | 9.5 | 1x5.15x4.5 m RC box | | 20 | 3.14 | |
| 612 | 201.400 | Kutcha Rd | F | 5.2 | 3 | 45 | 3 | 1x4x2.5 m RC box | | 33 | 2.15 | |
| 613 | 201.677 | Kutcha Rd | F | 3.9 | 3 | 36 | 3 | 1x4x2.5 m RC box | | 28 | 0.92 | |
| 614 | 201.791 | Village Rd | F | 6.8 | 4.3 | 27 | 5.5 | 1x5.15x4.5 m RC box | | 25 | 2.51 | |
| 615 | 202.668 | Village Rd | F | 5.8 | 4.3 | 5 | 5 | 1x5.15x4.5 m RC box | | 21 | 1.51 | |
| 616 | 203.065 | Village Rd | C | 0.3 | 8.4 | 25 | 3 | Mini ROB 1x12x7.5 RC box | 13 | | | |
| 617 | 203.153 | Kutcha Rd | C | 5.3 | 8.4 | 10 | 2.5 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 618 | 203.268 | Kutcha Rd | C | 11 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 619 | 203.390 | ODR | C | 4.9 | 8.4 | 60 | 7 | Mini ROB 1x12x7.5 RC box | 35 | | | |
| 620 | 203.560 | Kutcha Rd | C | 6.4 | 8.4 | 45 | 7 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 621 | 203.628 | Village Rd | C | 3.1 | 8.4 | 20 | 7 | Mini ROB 1x12x7.5 RC box | 11 | | | |
| 622 | 203.742 | Village Rd | F | 4.8 | 4.3 | 70 | 5 | 1x5.15x3.6 m RC box | | 75 | 0.53 | |
| 623 | 204.124 | SH | C | 0.8 | 9.39 | | | 6x30PSC Gr+150x2 RE approach | 461 | | | |
| 624 | 204.261 | Village Rd | F | 3.2 | 4.3 | 24 | 5.5 | 1x5.15x3.6 m RC box | | 25 | | 1.08 |
| 625 | 204.713 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 626 | 204.790 | Village Rd | F | 7.4 | 5.8 | | | Below Viaduct | | | | |
| 627 | 205.000 | Kutcha Rd | F | 15 | 4.7 | | | Below Viaduct | | | | |
| 628 | 205.167 | Kutcha Rd | F | 4.1 | 3 | 15 | 2.5 | 1x4x2.5 m RC box | | 22 | 1.11 | |
| 629 | 205.212 | ODR | F | 0.3 | 9.39 | | | 6x30PSC Gr+120x2 RE approach | 417 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 630 | 205.500 | Kutcha Rd | C | 9.9 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 631 | 205.545 | Kutcha Rd | C | 7.7 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 632 | 206.050 | Kutcha Rd | C | 11 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 633 | 206.658 | Kutcha Rd | C | 13 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 634 | 207.269 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 635 | 207.552 | Village Rd | F | 7 | 5.8 | | | Below Viaduct | | | | |
| 636 | 207.684 | ODR | F | 6 | 6.7 | | | Below Viaduct | | | | |
| 637 | 207.945 | Village Rd | F | 9 | 5.8 | | | Below Viaduct | | | | |
| 638 | 208.000 | SH | F | 8.2 | 7.7 | | | Below Viaduct | | | | |
| 639 | 208.100 | Village Rd | F | 7.6 | 5.8 | | | Below Viaduct | | | | |
| 640 | 208.608 | Village Rd | F | 7.3 | 5.8 | | | Below Viaduct | | | | |
| 641 | 208.650 | MDR | F | 8.1 | 7.7 | | | Below Viaduct | | | | |
| 642 | 208.770 | Kutcha Rd | F | 11 | 4.7 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 643 | 209.010 | Kutcha Rd | F | 11 | 4.7 | | | Below Viaduct | | | | |
| 644 | 209.200 | Kutcha Rd | F | 11 | 4.7 | | | Below Viaduct | | | | |
| 645 | 209.725 | Kutcha Rd | F | 8 | 4.7 | | | Below Viaduct | | | | |
| 646 | 209.870 | Village Rd | F | 6 | 5.8 | | | Below Viaduct | | | | |
| 647 | 210.043 | Village Rd | F | 7 | 5.8 | | | Below Viaduct | | | | |
| 648 | 210.178 | Village Rd | F | 5 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | 0.74 | |
| 649 | 210.338 | ODR | F | 3.8 | 5.2 | | | 1x5.15x4.5 m RC box | | 20 | | 1.36 |
| 650 | 210.611 | ODR | F | 4.2 | 5.2 | 60 | 6 | 1x5.15x4.5 m RC box | | 50 | | 1.05 |
| 651 | 210.627 | Village Rd | F | 4 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 0.3 |
| 652 | 210.957 | Kutcha Rd | F | 4.3 | 3 | | | 1x4x2.5 m RC box | | 20 | 1.33 | |
| 653 | 211.080 | Village Rd | F | 3 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 1.3 |
| 654 | 212.564 | Adjacent ROB | F | 1.5 | | | | 1x11.5x7.5 RC Box | | | | |
| 655 | 212.659 | Adj.. ROB | F | 1.7 | | | | 1x11.5x7.5 RC Box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 656 | 212.932 | ODR | F | 2.7 | 9.39 | | | 9x30PSC Gr+120x2 RE approach | 515 | | | |
| 657 | 213.172 | Village Rd | F | 2.8 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 1.5 |
| 658 | 213.491 | Village Rd | F | 4.3 | 4.3 | | 2.5 | 1x5.15x3.6 m RC box | | 20 | 0 | |
| 659 | 213.580 | Kutcha Rd | F | 7 | 3 | 45 | 4 | 1x4x2.5 m RC box | | 33 | 4 | |
| 660 | 214.070 | Kutcha Rd | F | 9.9 | 4.7 | | | Below Viaduct | | | | |
| 661 | 214.180 | Kutcha Rd | F | 8.8 | 4.7 | | | Below Viaduct | | | | |
| 662 | 214.240 | Kutcha Rd | F | 8.5 | 4.7 | | | Below Viaduct | | | | |
| 663 | 214.878 | Kutcha Rd | F | 3.5 | 3 | | | 1x4x2.5 m RC box | | 20 | 0.47 | |
| 664 | 214.910 | Adj… ROB | F | 2.1 | | | | 1x11.5x7.5 RC Box | | | | |
| 665 | 215.000 | Industry Rd | F | 4.3 | 6.2 | | | 1x5.15x5.5 m RC box | | 20 | | 1.95 |
| 666 | 215.638 | ODR | F | 4.7 | 9.39 | 23 | 11 | 17x30PSC Gr+150x2 RE approach | 762 | | | |
| 667 | 215.715 | Village Rd | F | 5.7 | 4.3 | 15 | | 1x5.15x3.6 m RC box | | 22 | 1.44 | |
| 668 | 215.880 | ODR * | F | 5.5 | 6.2 | 59 | 20 | 1x11.5x5.5 m RC box | | 60 | | 0.7 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 669 | 216.080 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 670 | 216.158 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 671 | 216.482 | Village Rd | F | 10 | 5.8 | | | Below Viaduct | | | | |
| 672 | 216.636 | Kutcha Rd | F | 6.4 | 4.7 | | | Below Viaduct | | | | |
| 673 | 216.920 | Kutcha Rd | F | 9.5 | 4.7 | | | Below Viaduct | | | | |
| 674 | 217.528 | ODR | F | 3.8 | 9.39 | 45 | 8 | 13x30PSC Gr+150x2 RE approach | 690 | | | |
| 675 | 217.592 | Village Rd | F | 1.5 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 2.8 |
| 676 | 217.749 | Village Rd | F | 3.7 | 4.3 | 50 | 4 | 1x5.15x3.6 m RC box | | 38 | | 0.6 |
| 677 | 217.895 | MDR | F | 0.3 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 678 | 217.992 | Kutcha Rd | C | 4.2 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 679 | 218.180 | Village Rd | F | 8.5 | 5.8 | | | Below Viaduct | | | | |
| 680 | 218.564 | Kutcha Rd | F | 9.4 | 4.7 | | | Below Viaduct | | | | |
| 681 | 219.341 | Kutcha Rd | F | 8.7 | 4.7 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 682 | 219.563 | Kutcha Rd | F | 6.3 | 4.7 | | | Below Viaduct | | | | |
| 683 | 219.724 | Kutcha Rd | F | 2.6 | 3 | 45 | | 1x4x2.5 m RC box | | 33 | | 0.4 |
| 684 | 219.928 | ODR | F | 3.9 | 9.39 | 50 | 5 | 11x30PSC Gr+120x2 RE approach | 560 | | | |
| 685 | 220.027 | Kutcha Rd | F | 1.7 | 3 | 60 | 5 | 1x4x2.5 m RC box | | 48 | | 1.29 |
| 686 | 220.205 | Village Rd | C | 4.5 | 8.4 | 33 | 6 | Mini ROB 1x12x7.5 RC box | 16 | | | |
| 687 | 220.319 | Kutcha Rd | C | 8 | 8.4 | 35 | 5 | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 688 | 220.395 | Village Rd | C | 9.3 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 689 | 221.035 | MDR | F | 7.5 | 7.7 | | 7.5 | Below Viaduct | | | | 0.2 |
| 690 | 222.003 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 691 | 222.562 | MDR | F | 7.3 | 7.7 | 34 | 7 | Below Viaduct | | | | 0.4 |
| 692 | 223.300 | ODR | F | 4 | 5.2 | 36 | 7.5 | 1x5.15x4.5 m RC box | | 29 | | 1.23 |
| 693 | 223.598 | Village Rd | F | 6.1 | 4.3 | 0 | 9 | 1x5.15x3.6 m RC box | | 20 | 1.8 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 694 | 223.850 | Village Rd | F | 5.5 | 4.3 | 35 | 4 | 1x5.15x3.6 m RC box | | 29 | 1.2 | |
| 695 | 223.966 | MDR | F | 5.8 | 6.7 | 53 | 8 | 1x10x5.5 m RC box | | 49 | | 0.94 |
| 696 | 224.870 | Kutcha Rd | F | 9.6 | 4.7 | | | Below Viaduct | | | | |
| 697 | 225.380 | Village Rd | F | 7 | 5.8 | | | Below Viaduct | | | | |
| 698 | 225.709 | Village Rd | F | 8.3 | 5.8 | | | Below Viaduct | | | | |
| 699 | 226.190 | MDR | F | 6.9 | 7.7 | | | Below Viaduct | | | | 0.76 |
| 700 | 226.206 | Village Rd | F | 6.7 | 5.8 | | | Below Viaduct | | | | |
| 701 | 226.572 | Kutcha Rd | F | 7.5 | 4.7 | | | Below Viaduct | | | | |
| 702 | 227.308 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 703 | 227.594 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 704 | 227.718 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 705 | 228.073 | Village Rd | F | 6.7 | 5.8 | | | Below Viaduct | | | | |
| 706 | 228.192 | MDR | F | 6.9 | 7.7 | | | Below Viaduct | | | | 0.8 |
| 707 | 228.315 | Village Rd | F | 7.2 | 5.8 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 708 | 228.788 | MDR | F | 7.3 | 7.7 | | | Below Viaduct | | | | 0.38 |
| 709 | 229.324 | Village Rd | F | 0 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 710 | 230.086 | MDR | C | 8.6 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 711 | 230.609 | Kutcha Rd | F | 5.4 | 3 | | | 1x4x2.5 m RC box | | 20 | 2.4 | |
| 712 | 230.937 | Village Rd | F | 8.8 | 5.8 | | | Below Viaduct | | | 3 | |
| 713 | 231.155 | ODR | F | 6.1 | 5.2 | 0 | 4.5 | 1x5.15x4.5 m RC box | | 20 | 0.9 | |
| 714 | 231.326 | MDR | F | 6.9 | 6.7 | 27 | | 1x10x5.5 m RC box | | 29 | 0.2 | |
| 715 | 231.400 | Kutcha Rd | F | 5.8 | 3 | 56 | 4 | 1x4x2.5 m RC box | | 43 | 2.8 | |
| 716 | 231.482 | Village Rd | F | 1.5 | 4.3 | 20 | 4 | 1x5.15x3.6 m RC box | | 23 | | 2.8 |
| 717 | 231.611 | Village Rd | C | 0.3 | 8.4 | 68 | 5 | Mini ROB 1x12x7.5 RC box | 49 | | | |
| 718 | 231.922 | Village Rd | F | 3.2 | 4.3 | | 3 | 1x5.15x3.6 m RC box | | 20 | | |
| 719 | 232.062 | Village Rd | F | 0.8 | 3 | | | 1x4x2.5 m RC box | | 20 | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 720 | 232.238 | MDR | F | 2.2 | 9.39 | 24 | 6 | 11x30PSC Gr+150x2 RE approach | 611 | | | |
| 721 | 232.348 | Kutcha Rd | F | 7.2 | 3 | 0 | 3 | 1x4x2.5 m RC box | | 20 | 4.2 | |
| 722 | 232.604 | Village Rd | F | 3.4 | 4.3 | 45 | 3 | 1x5.15x3.6 m RC box | | 34 | | 0.9 |
| 723 | 232.970 | Village Rd | C | 2.3 | 8.4 | 23 | 4 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 724 | 233.227 | MDR | C | 5.3 | 8.4 | 25 | 10 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 725 | 234.032 | Village Rd | F | 5.4 | 4.3 | 58 | | 1x5.15x3.6 m RC box | | 47 | 1.1 | |
| 726 | 234.143 | ODR | F | 4.2 | 5.2 | | 6.5 | 1x5.15x4.5 m RC box | | 20 | | 1 |
| 727 | 234.400 | SH | C | 3.7 | 8.4 | 11 | 8.5 | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 728 | 234.505 | Village Rd | C | 0 | 8.4 | 47 | 5 | Mini ROB 1x12x7.5 RC box | 23 | | | |
| 729 | 234.631 | Kutcha Rd | F | 5.3 | 3 | 45 | 3 | 1x4x2.5 m RC box | | 33 | 2.3 | |
| 730 | 234.771 | Kutcha Rd | F | 5.2 | 3 | | | 1x4x2.5 m RC box | | 20 | 2.2 | |
| 731 | 234.847 | Village Rd | F | 0 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW (m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 732 | 234.955 | ODR | F | 1.1 | 9.39 | 26 | 7 | 7x30PSC Gr+120x2 RE approach | 450 | | | |
| 733 | 235.300 | Kutcha Rd | F | 0.4 | 3 | | | 1x4x2.5 m RC box | | 20 | | 2.6 |
| 734 | 235.324 | Kutcha Rd | C | 0 | 3 | 40 | | 1x4x2.5 m RC box | | 30 | | 3 |
| 735 | 235.570 | Village Rd | C | 2.5 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 736 | 236.443 | Village Rd | F | 4.7 | 5.8 | | | Below Viaduct | | | | |
| 737 | 236.874 | ODR | F | 1.9 | 9.39 | 24 | 5.5 | 8x30PSC Gr+120x2 RE approach | 483 | | | |
| 738 | 236.976 | Kutcha Rd | F | 1.3 | 3 | 0 | 3 | 1x4x2.5 m RC box | | 20 | | 1.7 |
| 739 | 237.536 | Kutcha Rd | C | 0.7 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 740 | 238.210 | SH | C | 5.6 | 8.4 | 22 | 12 | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 741 | 238.933 | Kutcha Rd | F | 2.1 | 4.3 | 0 | 4 | 1x5.15x3.6 m RC box | | 20 | | 2.2 |
| 742 | 239.436 | Kutcha Rd | F | 5.2 | 3 | 0 | 3 | 1x4x2.5 m RC box | | 20 | 2.2 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 743 | 239.777 | Kutcha Rd | F | 3.9 | 3 | 0 | 3 | 1x4x2.5 m RC box | | 20 | 0.9 | |
| 744 | 240.305 | MDR | C | 0.5 | 8.4 | 23 | 6 | Mini ROB 1x12x7.5 RC box | 19 | | | |
| 745 | 240.665 | Kutcha Rd | F | 4 | 3 | 0 | 13 | 1x4x2.5 m RC box | | 20 | 1 | |
| 746 | 241.062 | Kutcha Rd | F | 5.7 | 3 | 0 | 3 | 1x4x2.5 m RC box | | 20 | 2.7 | |
| 747 | 241.264 | Village Rd | F | 5.2 | 4.3 | 10 | 5 | 1x5.15x3.6 m RC box | | 21 | 0.9 | |
| 748 | 243.051 | MDR | F | 5 | 6.7 | 47 | 5 | 1x10x5.5 m RC box | | 42 | | 1.7 |
| 749 | 243.129 | Kutcha Rd | F | 4.8 | 3 | | | 1x4x2.5 m RC box | | 20 | 1.8 | |
| 750 | 243.855 | ODR | F | 5 | 4.3 | 29 | 7 | 1x5.15x4.5 m RC box | | 26 | 0.7 | |
| 751 | 244.829 | Kutcha Rd | F | 5.3 | 3 | 67 | 3 | 1x4x2.5 m RC box | | 62 | 2.3 | |
| 752 | 245.112 | Kutcha Rd | F | 5.7 | 4.7 | | | Below Viaduct | | | | |
| 753 | 245.160 | Kutcha Rd | F | 5.7 | 4.7 | | | Below Viaduct | | | | |
| 754 | 245.300 | Kutcha Rd | F | 5.7 | 4.7 | | | Below Viaduct | | | | |
| 755 | 246.080 | ODR | F | 2.2 | 9.39 | 30 | 5 | 8x30PSC Gr+120x2 RE approach | 492 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 756 | 246.387 | Kutcha Rd | F | 5 | 3 | 45 | 3 | 1x4x2.5 m RC box | | 33 | 2 | |
| 757 | 246.482 | Kutcha Rd | F | 5 | 3 | 62 | 3 | 1x4x2.5 m RC box | | 52 | 2 | |
| 758 | 246.716 | Village Rd | F | 6.2 | 4.3 | 37 | 3.5 | 1x5.15x3.6 m RC box | | 30 | 1.9 | |
| 759 | 246.915 | ODR | F | 4.8 | 5.2 | | | 1x5.15x4.5 m RC box | | 20 | | 0.4 |
| 760 | 247.323 | Village Rd | F | 8.5 | 5.8 | | | Below Viaduct | | | | |
| 761 | 247.595 | SH | F | 8.3 | 7.7 | | | Below Viaduct | | | | |
| 762 | 247.685 | MDR | F | 8.5 | 7.7 | | | Below Viaduct | | | | |
| 763 | 248.690 | Village Rd | F | 6.1 | 5.8 | | | Below Viaduct | | | | |
| 764 | 249.103 | Village Rd | F | 5.5 | 5.8 | | | Below Viaduct | | | | |
| 765 | 250.060 | MDR | F | 1.8 | 9.39 | 45 | 15 | 10x30PSC Gr+150x2 RE approach | 588 | | | |
| 766 | 250.136 | ODR | C | 0.6 | 8.4 | 0 | 8 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 767 | 250.411 | Kutcha Rd | F | 0.1 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 768 | 251.036 | Village Rd | F | 2.9 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 1.4 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 769 | 251.400 | ODR | C | 1.3 | 8.4 | 15 | 6 | Mini ROB 1x12x7.5 RC box | 9.8 | | | |
| 770 | 251.587 | Village Rd | F | 0.8 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 3.5 |
| 771 | 251.753 | Kutcha Rd | F | 4.2 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1.2 | |
| 772 | 251.868 | MDR | F | 4.7 | 9.39 | 63 | 6 | 14x30PSC Gr+150x2 RE approach | 732 | | | |
| 773 | 252.000 | Kutcha Rd | F | 5.7 | 3 | 66 | 3 | 1x4x2.5 m RC Box | | 60 | 2.7 | |
| 774 | 252.137 | Kutcha Rd | F | 4.3 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1.3 | |
| 775 | 252.264 | Kutcha Rd | F | 2.3 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.7 |
| 776 | 252.343 | Kutcha Rd | F | 2.5 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.5 |
| 777 | 252.406 | Kutcha Rd | F | 3.7 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.7 | |
| 778 | 252.831 | ODR | F | 4.8 | 5.2 | | | 1x5.15x4.5 m RC box | | 20 | | 0.4 |
| 779 | 252.878 | Kutcha Rd | F | 8.1 | 3 | | | 1x4x2.5 m RC Box | | 20 | 5.1 | |
| 780 | 253.065 | Village Rd | F | 3.1 | 4.3 | 0 | 5 | 1x5.15x3.6 m RC box | | 20 | | 1.2 |
| 781 | 253.156 | Village Rd | F | 3.1 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 1.2 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 782 | 253.194 | Village Rd | F | 3.1 | 4.3 | 45 | 4 | 1x5.15x3.6 m RC box | | 34 | | 1.2 |
| 783 | 253.300 | Kutcha Rd | F | 1.4 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 1.6 |
| 784 | 253.367 | Village Rd | F | 1.4 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 2.9 |
| 785 | 253.876 | ODR | F | 4 | 5.2 | 0 | 8 | 1x5.15x4.5 m RC box | | 20 | | 1.2 |
| 786 | 254.336 | Kutcha Rd | C | 0.9 | 8.4 | 5 | 3 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 787 | 254.454 | Village Rd | C | 6.2 | 8.4 | 70 | 6 | Mini ROB 1x12x7.5 RC box | 54 | | | |
| 788 | 254.516 | MDR | C | 8.5 | 8.4 | 34 | 10 | CT&CR 1x13.25x7.5 RC box | | | | |
| 789 | 254.553 | Kutcha Rd | C | 8.2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 790 | 254.650 | ODR | C | 6 | 8.4 | 33 | 7.5 | Mini ROB 1x12x7.5 RC box | 16 | | | |
| 791 | 255.040 | Kutcha Rd | F | 1.4 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.6 |
| 792 | 255.161 | Kutcha Rd | F | 2.1 | 3 | 29 | 3 | 1x4x2.5 m RC Box | | 26 | | 0.9 |
| 793 | 255.197 | Village Rd | F | 2.5 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 1.8 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 794 | 255.403 | Kutcha Rd | F | 5.1 | 4.7 | | | Below Viaduct | | | | |
| 795 | 255.434 | Kutcha Rd | F | 5.5 | 4.7 | | | Below Viaduct | | | | |
| 796 | 255.707 | Village Rd | F | 5.5 | 4.7 | | | Below Viaduct | | | | |
| 797 | 256.115 | ODR | F | 7.8 | 6.7 | | | Below Viaduct | | | | |
| 798 | 256.580 | Village Rd | F | 9.5 | 5.8 | | | Below Viaduct | | | | |
| 799 | 256.677 | Kutcha Rd | F | 11 | 4.7 | | | Below Viaduct | | | | |
| 800 | 256.700 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 801 | 256.734 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 802 | 256.832 | Village Rd | F | 13 | 5.8 | | | Below Viaduct | | | | |
| 803 | 256.966 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 804 | 257.045 | Village Rd | F | 7 | 5.8 | | | Below Viaduct | | | | |
| 805 | 257.130 | MDR | F | 6.8 | 7.7 | 45 | 14 | Below Viaduct | | | | |
| 806 | 257.231 | Village Rd | F | 7.4 | 5.8 | | | Below Viaduct | | | | |
| 807 | 257.326 | Village Rd | F | 9 | 5.8 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 808 | 257.464 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 809 | 257.506 | Village Rd | F | 14 | 5.8 | | | Below Viaduct | | | | |
| 810 | 257.605 | Kutcha Rd | F | 21 | 4.7 | | | Below Viaduct | | | | |
| 811 | 257.649 | Kutcha Rd | F | 21 | 4.7 | | | Below Viaduct | | | | |
| 812 | 257.698 | Kutcha Rd | F | 22 | 4.7 | | | Below Viaduct | | | | |
| 813 | 257.762 | Village Rd | F | 19 | 5.8 | | | Below Viaduct | | | | |
| 814 | 257.820 | Kutcha Rd | F | 17 | 4.7 | | | Below Viaduct | | | | |
| 815 | 258.013 | MDR | F | 12 | 7.7 | | | Below Viaduct | | | | |
| 816 | 258.130 | Village Rd | F | 12 | 5.8 | | | Below Viaduct | | | | |
| 817 | 258.231 | Village Rd | F | 16 | 5.8 | | | Below Viaduct | | | | |
| 818 | 258.400 | Kutcha Rd | F | 18 | 4.7 | | | Below Viaduct | | | | |
| 819 | 258.510 | Village Rd | F | 17 | 5.8 | | | Below Viaduct | | | | |
| 820 | 258.548 | Village Rd | F | 18 | 5.8 | | | Below Viaduct | | | | |
| 821 | 258.667 | Kutcha Rd | F | 22 | 4.7 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 822 | 258.680 | Kutcha Rd | F | 20 | 4.7 | | | Below Viaduct | | | | |
| 823 | 258.711 | Kutcha Rd | F | 25 | 4.7 | | | Below Viaduct | | | | |
| 824 | 258.966 | Kutcha Rd | F | 23 | 4.7 | | | Below Viaduct | | | | |
| 825 | 259.074 | Kutcha Rd | F | 20 | 4.7 | | | Below Viaduct | | | | |
| 826 | 259.700 | Village Rd | F | 24 | 5.8 | | | Below Viaduct | | | | |
| 827 | 259.763 | MDR | F | 24 | 7.7 | | | Below Viaduct | | | | |
| 828 | 259.988 | MDR | F | 24 | 7.7 | | | Below Viaduct | | | | |
| 829 | 260.100 | Village Rd | F | 23 | 5.8 | | | Below Viaduct | | | | |
| 830 | 260.315 | MDR | F | 21 | 7.7 | | | Below Viaduct | | | | |
| 831 | 260.808 | MDR | F | 18 | 7.7 | | | Below Viaduct | | | | |
| 832 | 261.149 | ODR | F | 16 | 6.7 | | | Below Viaduct | | | | |
| 833 | 261.927 | MDR | F | 17 | 7.7 | | | Below Viaduct | | | | |
| 834 | 262.133 | SH | F | 15 | 7.7 | | | Below Viaduct | | | | |
| 835 | 262.287 | Village Rd | F | 15 | 5.8 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cut over | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 836 | 262.351 | Village Rd | F | 16 | 5.8 | | | Below Viaduct | | | | |
| 837 | 262.496 | Village Rd | F | 17 | 5.8 | | | Below Viaduct | | | | |
| 838 | 263.965 | Kutcha Rd | F | 4.8 | 4.7 | | | Below Viaduct | | | | |
| 839 | 264.262 | Village Rd | F | 5 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | 0.7 | |
| 840 | 264.707 | Village Rd | F | 3.6 | 4.3 | 45 | 6.5 | 1x5.15x3.6 m RC box | | 34 | | 0.7 |
| 841 | 264.780 | Village Rd | F | 3 | 4.3 | 50 | 5 | 1x5.15x3.6 m RC box | | 38 | | 1.3 |
| 842 | 264.819 | Village Rd | F | 3.3 | 4.3 | 28 | 4 | 1x5.15x3.6 m RC box | | 26 | | 1 |
| 843 | 264.908 | Kutcha Rd | F | 3.8 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.8 | |
| 844 | 265.046 | Kutcha Rd | F | 7 | 4.7 | | | Below Viaduct | | | | |
| 845 | 265.166 | Village Rd | F | 8.2 | 5.8 | | | Below Viaduct | | | | |
| 846 | 265.258 | Village Rd | F | 7.5 | 5.8 | | | Below Viaduct | | | | |
| 847 | 265.318 | Village Rd | F | 7.2 | 5.8 | | | Below Viaduct | | | | |
| 848 | 265.369 | MDR | F | 7.1 | 7.7 | | | Below Viaduct | | | | |
| 849 | 265.530 | Kutcha Rd | F | 8.9 | 4.7 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 850 | 265.565 | Kutcha Rd | F | 9.2 | 4.7 | | | Below Viaduct | | | | |
| 851 | 265.590 | ODR | F | 9.5 | 6.7 | | | Below Viaduct | | | | |
| 852 | 265.888 | ODR | F | 12 | 6.7 | | | Below Viaduct | | | | |
| 853 | 266.239 | Village Rd | F | 6 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 34 | 1.7 | |
| 854 | 266.355 | Kutcha Rd | F | 4.2 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1.2 | |
| 855 | 266.464 | Village Rd | F | 4.5 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | 0.2 | |
| 856 | 266.585 | Village Rd | F | 3.5 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 0.8 |
| 857 | 266.629 | Kutcha Rd | F | 3 | 3 | 45 | | 1x4x2.5 m RC Box | | 33 | 0 | |
| 858 | 266.717 | MDR | F | 1.3 | 9.39 | | | 9x30PSC Gr+150x2 RE approach | 566 | | | |
| 859 | 266.887 | Village Rd | F | 2.5 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 34 | | 1.8 |
| 860 | 267.033 | Kutcha Rd | F | 4.3 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1.3 | |
| 861 | 267.268 | Village Rd | F | 6 | 4.3 | 50 | | 1x5.15x3.6 m RC box | | 38 | 1.7 | |
| 862 | 267.574 | Kutcha Rd | F | 7.1 | 3 | 30 | | 1x4x2.5 m RC Box | | 26 | 4.1 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 863 | 267.726 | Kutcha Rd | F | 5.2 | 3 | 60 | | 1x4x2.5 m RC Box | | 48 | 2.2 | |
| 864 | 267.796 | Village Rd | F | 4.3 | 4.3 | 15 | | 1x5.15x3.6 m RC box | | 22 | 0 | |
| 865 | 268.347 | Kutcha Rd | F | 7.8 | 4.7 | | | Below Viaduct | | | | |
| 866 | 268.454 | Kutcha Rd | F | 7.8 | 4.7 | | | Below Viaduct | | | | |
| 867 | 269.151 | MDR | F | 3.4 | 9.39 | 50 | 9 | 12x30PSC Gr+150x2 RE approach | 670 | | | |
| 868 | 269.230 | Village Rd | F | 1.8 | 4.3 | 45 | 4 | 1x5.15x3.6 m RC box | | 34 | | 2.5 |
| 869 | 269.300 | Village Rd | F | 1.6 | 4.3 | 50 | 4 | 1x5.15x3.6 m RC box | | 38 | | 2.7 |
| 870 | 269.379 | MDR | F | 1 | 9.39 | 45 | 11 | 8x30PSC Gr+150x2 RE approach | 551 | | | |
| 871 | 269.541 | Kutcha Rd | C | 2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 872 | 269.568 | Kutcha Rd | C | 2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 873 | 270.100 | MDR | C | 2.7 | 8.4 | 40 | 9 | Mini ROB 1x12x7.5 RC box | 27 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 874 | 270.219 | Kutcha Rd | C | 5.3 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 875 | 270.300 | Village Rd | C | 6 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 876 | 270.360 | Kutcha Rd | C | 5 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 877 | 270.490 | Kutcha Rd | C | 2.5 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 878 | 270.819 | Village Rd | F | 5.6 | 4.3 | 10 | 6 | 1x5.15x3.6 m RC box | | 21 | 1.3 | |
| 879 | 271.225 | Kutcha Rd | F | 6 | 3 | | | 1x4x2.5 m RC Box | | 20 | 3 | |
| 880 | 271.328 | MDR | F | 2.2 | 9.39 | 45 | 7 | 10x30PSC Gr+150x2 RE approach | 608 | | | |
| 881 | 271.480 | MDR | F | 0.3 | 8.4 | 45 | 6 | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 882 | 271.821 | Kutcha Rd | F | 4.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1.9 | |
| 883 | 272.000 | Kutcha Rd | F | 3.2 | 3 | 45 | 3 | 1x4x2.5 m RC Box | | 33 | 0.2 | |
| 884 | 272.098 | ODR | C | 2.6 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 22 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 885 | 272.311 | Village Rd | F | 1.6 | 4.3 | 45 | 5 | 1x5.15x3.6 m RC box | | 34 | | 2.7 |
| 886 | 272.695 | Village Rd | F | 6.2 | 5.8 | | | Below Viaduct | | | | |
| 887 | 273.190 | ODR | C | 3.5 | 8.4 | 14 | 7 | Mini ROB 1x12x7.5 RC box | 9.5 | | | |
| 888 | 273.330 | Village Rd | C | 1.7 | 8.4 | 50 | 3 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 889 | 273.454 | Kutcha Rd | F | 4.6 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 890 | 273.589 | Village Rd | F | 7.5 | 4.3 | 62 | 7 | 1x5.15x3.6 m RC box | | 54 | 3.2 | |
| 891 | 273.730 | Kutcha Rd | F | 6.5 | 3 | 71 | 5 | 1x4x2.5 m RC Box | | 75 | 3.5 | |
| 892 | 273.919 | Kutcha Rd | F | 5.1 | 3 | 25 | 5 | 1x4x2.5 m RC Box | | 24 | 2.1 | |
| 893 | 274.098 | ODR | F | 1.7 | 5.2 | 20 | 9 | 1x5.15x4.5 m RC box | | 23 | | 3.5 |
| 894 | 274.157 | Kutcha Rd | F | 2.5 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.5 |
| 895 | 274.281 | Kutcha Rd | F | 4.8 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1.8 | |
| 896 | 274.780 | ODR | F | 0.2 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 897 | 274.968 | Kutcha Rd | F | 0.2 | 8.4 | 30 | 3 | Mini ROB 1x12x7.5 RC box | 13 | | | |
| 898 | 275.196 | Village Rd | F | 5.9 | 4.3 | 45 | 4 | 1x5.15x3.6 m RC box | | 34 | 1.6 | |
| 899 | 275.287 | Village Rd | F | 8.4 | 5.8 | | | Below Viaduct | | | | |
| 900 | 275.587 | Village Rd | F | 8.3 | 5.8 | | | Below Viaduct | | | | |
| 901 | 275.842 | Village Rd | F | 2.5 | 4.3 | 45 | 7 | 1x5.15x3.6 m RC box | | 34 | | 1.8 |
| 902 | 275.970 | SH | F | 0.5 | 9.39 | 25 | 11 | 8x30PSC Gr+150x2 RE approach | 527 | | | |
| 903 | 276.047 | Village Rd | F | 0.9 | 4.3 | 10 | 4 | 1x5.15x3.6 m RC box | | 21 | | 3.4 |
| 904 | 276.553 | MDR | F | 8.6 | 7.7 | | | Below Viaduct | | | | |
| 905 | 276.683 | ODR | F | 8.3 | 6.7 | | | Below Viaduct | | | | |
| 906 | 276.897 | Village Rd | F | 4.2 | 4.3 | 10 | | 1x5.15x3.6 m RC box | | 21 | | 0.1 |
| 907 | 277.010 | Kutcha Rd | F | 2.6 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.4 |
| 908 | 277.210 | ODR | F | 1.7 | 9.39 | 45 | 6.5 | 8x30PSC Gr+120x2 RE approach | 472 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 909 | 277.822 | Village Rd | F | 3.7 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 34 | | 0.6 |
| 910 | 278.780 | Kutcha Rd | F | 2.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.1 |
| 911 | 279.074 | MDR | F | 2.5 | 9.39 | 45 | 5.5 | 11x30PSC Gr+150x2 RE approach | 625 | | | |
| 912 | 280.087 | Village Rd | F | 2.4 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 1.9 |
| 913 | 280.913 | Kutcha Rd | C | 0.3 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 914 | 281.445 | Village Rd | F | 2.7 | 4.3 | 10 | 3.5 | 1x5.15x3.6 m RC box | | 21 | | 1.6 |
| 915 | 281.833 | Village Rd | F | 1.9 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 2.4 |
| 916 | 282.000 | MDR | C | 6.2 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 917 | 282.171 | Village Rd | C | 6.2 | 8.4 | 0 | 4 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 918 | 283.012 | Kutcha Rd | F | 3 | 3 | 45 | 3 | 1x4x2.5 m RC Box | | 33 | 0 | |
| 919 | 283.346 | Kutcha Rd | F | 0.8 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 2.2 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 920 | 283.449 | SH | F | 0.8 | 9.39 | 25 | 19 | 8x30PSC Gr+150x2 RE approach | 539 | | | |
| 921 | 283.561 | Village Rd | F | 1.6 | 4.3 | 64 | 4.8 | 1x5.15x3.6 m RC box | | 58 | | 2.7 |
| 922 | 283.910 | Village Rd | C | 5.1 | 8.4 | 22 | 5.5 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 923 | 284.223 | Village Rd | C | 2 | 8.4 | 45 | 6 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 924 | 284.450 | Village Rd | F | 4.1 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 34 | | |
| 925 | 284.855 | Village Rd | C | 7.4 | 8.4 | 57 | 5 | Mini ROB 1x12x7.5 RC box | 32 | | | |
| 926 | 284.916 | ODR | C | 14 | 8.4 | 30 | 6 | CT&CR 1x13.25x7.5 RC box | | | | |
| 927 | 285.048 | Village Rd | C | 11 | 8.4 | 0 | 3.1 | CT&CR 1x13.25x7.5 RC box | | | | |
| 928 | 285.432 | MDR | F | 8.6 | 7.7 | 70 | 11 | Below Viaduct | | | | |
| 929 | 285.636 | Village Rd | F | 8 | 5.8 | 0 | | Below Viaduct | | | | |
| 930 | 285.800 | Village Rd | F | 5.1 | 4.3 | 45 | 4.5 | 1x5.15x3.6 m RC box | | 34 | | 0.8 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 931 | 286.006 | Kutcha Rd | C | 1.4 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 932 | 286.161 | ODR | C | 6 | 8.4 | 50 | 7.5 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 933 | 286.271 | Village Rd | C | 7.8 | 8.4 | 50 | 5.5 | Mini ROB 1x12x7.5 RC box | 25 | | | |
| 934 | 286.762 | MDR | C | 12 | 8.4 | 10 | 9.3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 935 | 287.319 | MDR | C | 1.2 | 8.4 | 50 | 13 | Mini ROB 1x12x7.5 RC box | 35 | | | |
| 936 | 287.917 | ODR | C | 1.1 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 937 | 288.082 | Village Rd | C | 15 | 8.4 | 45 | 4.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 938 | 288.278 | ODR | C | 12 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 939 | 289.039 | MDR | C | 9 | 8.4 | 45 | 10 | CT&CR 1x13.25x7.5 RC box | | | | |
| 940 | 289.185 | Village Rd | C | 3 | 8.4 | 30 | 4.5 | Mini ROB 1x12x7.5 RC box | 15 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 941 | 290.159 | Village Rd | C | 3.5 | 8.4 | 0 | 3 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 942 | 290.241 | MDR | C | 3.7 | 8.4 | 0 | 6.5 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 943 | 290.700 | Village Rd | C | 9.6 | 8.4 | 45 | 4.8 | CT&CR 1x13.25x7.5 RC box | | | | |
| 944 | 291.524 | SH | F | 3.2 | 9.39 | 35 | 14 | 12x30PSC Gr+150x2 RE approach | 661 | | | |
| 945 | 291.946 | Village Rd | C | 0.2 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 946 | 293.033 | MDR | C | 8 | 8.4 | 20 | 6 | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 947 | 293.343 | MDR | C | 10 | 8.4 | 25 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 948 | 293.685 | Village Rd | F | 7.4 | 4.3 | 45 | 4.5 | 1x5.15x3.6 m RC box | | 34 | 3.1 | |
| 949 | 293.743 | Village Rd | F | 7 | 4.3 | 45 | 3 | 1x5.15x3.6 m RC box | | 34 | 27 | |
| 950 | 294.176 | VIllage Rd | F | 3.7 | 4.3 | 50 | 3 | 1x5.15x3.6 m RC box | | 38 | | 0.6 |
| 951 | 294.789 | Village Rd | C | 6.3 | 8.4 | 45 | 5 | Mini ROB 1x12x7.5 RC box | 22 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 952 | 294.950 | Village Rd | C | 6.1 | 8.4 | | 3.5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 953 | 295.130 | Kutcha Rd | F | 3.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.9 | |
| 954 | 295.314 | Village Rd | F | 5.2 | 4.3 | 45 | 5 | 1x5.15x3.6 m RC box | | 34 | 0.9 | |
| 955 | 295.404 | Village Rd | F | 6 | 4.3 | 45 | 3 | 1x5.15x3.6 m RC box | | 34 | 1.7 | |
| 956 | 296.880 | MDR | F | 3.5 | 9.39 | 10 | | 12x30PSC Gr+150x2 RE approach | 672 | | | |
| 957 | 297.000 | Village Rd | F | 3.1 | 4.3 | 70 | | 1x5.15x3.6 m RC box | | 75 | | 1.2 |
| 958 | 297.100 | Kutcha Rd | F | 3.5 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.5 | |
| 959 | 297.212 | Village Rd | F | 3.3 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 27 | | 1 |
| 960 | 297.324 | Village Rd | F | 4.2 | 4.3 | | | 1x5.15x3.6 m RC box | | 20 | | 0.1 |
| 961 | 297.857 | Kutcha Rd | F | 3.8 | 3 | 45 | 3 | 1x4x2.5 m RC Box | | 33 | 0.8 | |
| 962 | 298.039 | MDR | C | 0.2 | 8.4 | 28 | 13 | Mini ROB 1x12x7.5 RC box | 21 | | | |
| 963 | 298.222 | Kutcha Rd | C | 3.4 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 964 | 298.285 | Village Rd | C | 2.8 | 8.4 | 30 | 4 | Mini ROB 1x12x7.5 RC box | 15 | | | |
| 965 | 298.414 | Village Rd | F | 3 | 4.3 | 45 | 3.5 | 1x5.15x3.6 m RC box | | 34 | | 1.3 |
| 966 | 298.630 | Village Rd | F | 3.8 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 27 | | 0.5 |
| 967 | 298.696 | Kutcha Rd | F | 3.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.9 | |
| 968 | 299.275 | ODR | F | 4.9 | 5.2 | | | 1x5.15x4.5 m RC box | | 20 | | 0.3 |
| 969 | 299.396 | Kutcha Rd | F | 4.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.9 | |
| 970 | 299.405 | Kutcha Rd | F | 4.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.9 | |
| 971 | 299.500 | Kutcha Rd | F | 5.7 | 3 | | | 1x4x2.5 m RC Box | | 20 | 2.7 | |
| 972 | 299.729 | Kutcha Rd | F | 5.8 | 3 | | | 1x4x2.5 m RC Box | | 20 | 2.8 | |
| 973 | 299.816 | Kutcha Rd | F | 5.3 | 3 | | | 1x4x2.5 m RC Box | | 20 | 2.3 | |
| 974 | 300.252 | Village Rd | C | 2.4 | 8.4 | 10 | 3 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 975 | 300.413 | Village Rd | F | 1.9 | 4.3 | 20 | 3.5 | 1x5.15x3.6 m RC box | | 23 | | 2.4 |
| 976 | 300.669 | Kutcha Rd | F | 2.7 | 3 | 50 | 3 | 1x4x2.5 m RC Box | | 37 | | 0.3 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 977 | 300.789 | NH | C | 3.9 | 8.4 | 48 | 15 | Mini ROB 1x12x7.5 RC box | 61 | | | |
| 978 | 300.900 | Village Rd | C | 11 | 8.4 | 0 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 979 | 301.068 | Kutcha Rd | C | 8.4 | 8.4 | 45 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 980 | 302.465 | Village Rd | C | 6.6 | 8.4 | 10 | 5 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 981 | 302.573 | MDR | C | 8.9 | 8.4 | 45 | 6.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 982 | 302.685 | Kutcha Rd | C | 7.2 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 983 | 302.838 | Village Rd | C | 4 | 8.4 | 57 | 3 | Mini ROB 1x12x7.5 RC box | 32 | | | |
| 984 | 303.318 | Kutcha Rd | C | 6.4 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 985 | 303.571 | Kutcha Rd | C | 10 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 986 | 303.628 | Village Rd | C | 9.6 | 8.4 | 0 | 3 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW (m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 987 | 303.663 | Kutcha Rd | C | 8.5 | 8.4 | 0 | 2.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 988 | 304.150 | Kutcha Rd | F | 0.7 | 3 | 0 | 3.5 | 1x4x2.5 m RC Box | | 20 | | 2.3 |
| 989 | 304.286 | Kutcha Rd | C | 2 | 8.4 | 45 | 4 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 990 | 304.700 | MDR | F | 6.2 | 6.7 | 10 | 11 | 1x10x5.5 m RC box | | 22 | | 0.5 |
| 991 | 304.780 | NH | F | 5.8 | 7 | 5 | 25 | 2x18 m PSc gr | | | | 1.2 |
| 992 | 305.263 | Kutcha Rd | F | 7.4 | 3 | 15 | 3 | 1x4x2.5 m RC Box | | 22 | 4.4 | |
| 993 | 305.819 | Village Rd | F | 7.3 | 4.3 | 0 | 5 | 1x5.15x3.6 m RC box | | 20 | 3 | |
| 994 | 305.978 | Village Rd | F | 2 | 4.3 | 10 | 9 | 1x5.15x3.6 m RC box | | 21 | | 2.3 |
| 995 | 306.257 | Kutcha Rd | F | 0.8 | 3 | 60 | 3 | 1x4x2.5 m RC Box | | 48 | | 2.2 |
| 996 | 306.323 | Kutcha Rd | F | 3.4 | 3 | 10 | 3 | 1x4x2.5 m RC Box | | 21 | 0.4 | |
| 997 | 307.642 | Kutcha Rd | F | 6.4 | 3 | 70 | 3 | 1x4x2.5 m RC Box | | 72 | 3.4 | |
| 998 | 307.694 | MDR | F | 6.2 | 6.7 | 10 | 9 | 1x10x5.5 m RC box | | 22 | | 0.5 |
| 999 | 307.731 | Kutcha Rd | F | 6.5 | 3 | 0 | 2 | 1x4x2.5 m RC Box | | 20 | 3.5 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1000 | 307.936 | Kutcha Rd | F | 7.6 | 3 | 5 | 3 | 1x4x2.5 m RC Box | | 20 | 4.6 | |
| 1001 | 308.422 | Village Rd | F | 7.4 | 5.8 | | | Below Viaduct | | | | |
| 1002 | 308.450 | Village Rd | F | 7.3 | 5.8 | | | Below Viaduct | | | | |
| 1003 | 308.624 | Kutcha Rd | F | 4.4 | 4.7 | 45 | 4 | Below Viaduct | | | | |
| 1004 | 309.252 | Kutcha Rd | F | 0.4 | 3 | 45 | 3 | 1x4x2.5 m RC Box | | 33 | | 2.6 |
| 1005 | 309.431 | Kutcha Rd | F | 3.3 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.3 | |
| 1006 | 311.259 | MDR | C | 0.4 | 8.4 | 15 | 7 | Mini ROB 1x12x7.5 RC box | 16 | | | |
| 1007 | 313.612 | Village Rd | F | 2.7 | 4.3 | | 3 | 1x5.15x3.6 m RC box | | 20 | | 1.6 |
| 1008 | 314.786 | Adj.. ROB | F | 1.7 | | | | 1x11.5x7.5 RC Box | | | | |
| 1009 | 316.431 | Adj.. ROB | C | 2.4 | | | | 1x11.5x7.5 RC Box | | | | |
| 1010 | 317.694 | Kutcha Rd | F | 4 | 3 | | | 1x4x2.5 m RC Box | | 20 | 1 | |
| 1011 | 317.738 | Kutcha Rd | F | 4.3 | 3 | | | 1x4x2.5 m+1x10x5 RC Box | | 20 | 1.3 | |
| 1012 | 319.753 | Adj.. ROB | F | 0.4 | | | | 1x11.5x7.5 RC Box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1013 | 319.904 | Kutcha Rd | F | 0.6 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 2.4 |
| 1014 | 319.951 | Kutcha Rd | F | 1 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 2 |
| 1015 | 319.981 | Kutcha Rd | F | 1.5 | 3 | 45 | 3 | 1x4x2.5 m RC Box | | 33 | | 1.5 |
| 1016 | 322.648 | Kutcha Rd | F | 2.9 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.1 |
| 1017 | 322.792 | Adj.. ROB | F | 3.2 | | 45 | 8 | 1x11.5x7.5 RC Box | | | | |
| 1018 | 324.386 | Kutcha Rd | F | 3.8 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.8 | |
| 1019 | 324.444 | Kutcha Rd | F | 3.5 | 3 | | | 1x4x2.5 m RC Box | | 20 | 0.5 | |
| 1020 | 324.768 | Village Rd | F | 0.1 | 4.3 | | | 1x6x3.6 RC Box | | 30 | | 4.2 |
| 1021 | 325.135 | LC | F | 1.9 | 9.39 | 10 | 6 | 11x30PSC Gr+150x2 RE approach | 622 | | | |
| 1022 | 327.958 | Kutcha Rd | F | 9.4 | 6 | | 8 | 1x8x5 m RC Box | | 30 | 1.4 | |
| 1023 | 328.762 | LC | C | 0.4 | 9.39 | | | 6x30PSC Gr+150x2 RE approach | 414 | | | |
| 1024 | 329.500 | Kutcha Rd | F | 2.6 | 3 | | | 1x4x2.5 m RC Box | | 20 | | 0.4 |
| 1025 | 330.056 | Kutcha Rd | F | 2.1 | 3 | | | 1x6x5 m RC Box | | 30 | | 0.9 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1026 | 330.724 | LC | F | 1.9 | 9.39 | 45 | 6 | 11x30PSC Gr+150x2 RE approach | 625 | | | |
| 1027 | 331.507 | Kutcha Rd | F | 2.76 | 5.8 | | | 1x6x5 m RC Box | | 30 | | 3.04 |
| 1028 | 331.816 | Village Rd | F | 4.5 | 5.8 | | | 1x6x5 m RC Box | | 30 | | 1.3 |
| 1029 | 333.508 | Adj.. ROB | | | | | | 1x11.5x7.5 RC Box | | | | |
| 1030 | 334.250 | Village Rd | F | 1 | 5.4 | | | 1x7x4.5 m RC Box | | 30 | | 4.4 |
| 1031 | 334.808 | MDR | F | 2.5 | 6.4 | | | 1x12m PSC GR | | 30 | | 3.9 |
| 1032 | 335.667 | MDR/ LC | F | 0.2 | 9.39 | | | 8x30PSC Gr+150x2 RE approach | 538 | | | |
| 1033 | 340.635 | ODR/ LC | C | 1.2 | 9.39 | 0 | 6 | 10x30PSC Gr+120x2 RE approach | 530 | | | |
| 1034 | 343.613 | MDR/ LC | F | 2 | 9.39 | 30 | 7 | 11x30PSC Gr+150x2 RE approach | 630 | | | |
| 1035 | 344.624 | Village Rd | F | 0.9 | 4.3 | 0 | 3 | 1x5.15x3.6 m RC box | | 20 | | 3.4 |
| 1036 | 345.087 | ODR/ LC | F | 0.6 | 9.39 | 2 | 7 | 8x30PSC Gr+120x2 RE approach | 461 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1037 | 347.032 | Adj.. ROB | c | 4 | | 30 | 10 | 1x11.5x7.5 RC Box | | | | |
| 1038 | 349.327 | Adj,, ROB | C | 5.5 | | 0 | 6 | 1x11.5x7.5 RC Box | | | | |
| 1039 | 350.216 | Village Rd | F | 3 | 5.7 | 0 | 4.3 | 1x4.5x5 m RC box | | 30 | | 2.7 |
| 1040 | 353.012 | Kutcha Rd | F | 1.8 | 5.7 | | | 1x4.5x5 m RC box | | 30 | | 3.9 |
| 1041 | 353.300 | SH | C | 1.3 | 9.39 | 45 | 10 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1042 | 353.825 | Kutcha Rd | C | 19 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1043 | 353.947 | Kutcha Rd | C | 13 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1044 | 354.035 | Village Rd | C | 6 | 3.25 | 0 | 4 | 1x3.5x2.75 m RC Box | | 30 | 2.75 | |
| 1045 | 354.273 | Kutcha Rd | C | 9.5 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1046 | 354.343 | Kutcha Rd | C | 11 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1047 | 354.390 | Village Rd | C | 12 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1048 | 354.550 | Village Rd | C | 15 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1049 | 354.632 | Kutcha Rd | C | 16 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1050 | 354.719 | Kutcha Rd | C | 18 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1051 | 354.790 | Kutcha Rd | C | 18 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1052 | 360.230 | ODR | C | 18 | 8.4 | 0 | 5.3 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1053 | 360.512 | Village Rd | C | 15 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1054 | 360.693 | Village Rd | C | 11 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1055 | 360.800 | Village Rd | C | 10 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1056 | 362.918 | ODR/ LC | F | 3.5 | 9.39 | 0 | 5.5 | 9x30PSC Gr+120x2 RE approach | 576 | | | |
| 1057 | 363.149 | LC | F | 2.5 | 9.39 | 10 | 6.5 | 12x30PSC Gr+120x2 RE approach | 600 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1058 | 364.124 | LC | F | 3 | 9.39 | 0 | 4.5 | 12x30PSC Gr+120x2 RE approach | 600 | | | |
| 1059 | 365.500 | Adj.. ROB | F | 0.9 | | 0 | 12 | 1x11.5x7.5 RC Box | | | | |
| 1060 | 366.675 | NH | C | 1 | 9.39 | 45 | 8+5 | 11x30PSC Gr+120x2 RE approach | 811 | | | |
| 1061 | 368.797 | Village Rd | F | 8.7 | 5.8 | | | Below Viaduct | | | | |
| 1062 | 368.934 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 1063 | 368.989 | Kutcha Rd | F | 10 | 4.7 | | | Below Viaduct | | | | |
| 1064 | 369.100 | NH | F | 9 | 7.7 | 70 | 9 | Below Viaduct | | | | |
| 1065 | 370.100 | NH | F | 11 | 7.7 | | | Below Viaduct | | | | |
| 1066 | 370.300 | ODR | F | 11 | 6.7 | | | Below Viaduct | | | | |
| 1067 | 370.511 | Village Rd | F | 11 | 5.8 | | | Below Viaduct | | | | |
| 1068 | 370.948 | Kutcha Rd | F | 11 | 4.7 | | | Below Viaduct | | | | |
| 1069 | 371.251 | Kutcha Rd | F | 8.5 | 4.7 | | | Below Viaduct | | | | |
| 1070 | 371.333 | Kutcha Rd | F | 7.9 | 4.7 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1071 | 371.354 | Kutcha Rd | F | 7.8 | 4.7 | | | Below Viaduct | | | | |
| 1072 | 371.394 | Village Rd | F | 7.3 | 5.8 | | | Below Viaduct | | | | |
| 1073 | 371.679 | MDR | F | 7.1 | 7.7 | | | Below Viaduct | | | | |
| 1074 | 371.700 | NH | F | 7 | 7.7 | | | Below Viaduct | | | | |
| 1075 | 371.900 | NH | F | 7.1 | 7.7 | | | Below Viaduct | | | | |
| 1076 | 372.150 | Village Rd | F | 8.2 | 5.8 | | | Below Viaduct | | | | |
| 1077 | 372.564 | Village Rd | F | 5.5 | 5.8 | 20 | 4 | 1X5.15X3.6 RCBOX | | 22 | | 0.3 |
| 1078 | 374.110 | MDR | C | 0.3 | 9.39 | 10 | 7 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1079 | 375.362 | LC | C | 1.5 | 9.39 | 25 | 6 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1080 | 377.181 | Village Rd | F | 0.5 | 9.39 | | | 7x30PSC Gr+120x2 RE approach | 454 | | | |
| 1081 | 377.340 | LC | F | 0.5 | 9.39 | 0 | 5 | 7x30PSC Gr+120x2 RE approach | 456 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1082 | 379.244 | Adj.. ROB | F | 0.8 | 8.9 | 45 | 7.5 | 1x11.5x7.5 RC Box | | | | 8.1 |
| 1083 | 381.200 | MDR | F | 2.2 | 6.2 | 0 | 6 | 1x6x5.5 m RC Box | | 30 | | 4 |
| 1084 | 381.534 | Adj.. ROB | F | 2.9 | 8.9 | 0 | 7 | 1x11.5x7.5 RC Box | | | | 6 |
| 1085 | 383.700 | MDR | F | 1.6 | 9.39 | | | 11x30PSC Gr+150x2 RE approach | 630 | | 13.34 m, dist. bet. Nearest exg. Track & CL of pro. SG tracks. | |
| 1086 | 384.410 | MDR | F | 0.94 | 9.39 | | | 10x30PSC Gr+150x2 RE approach | 600 | | 21.63m | |
| 1087 | 388.622 | NH | F | 0.4 | 9.39 | | | 13x30PSC Gr+240x2 RE approach | 870 | | Distance 12.23 m | |
| 1088 | 389.113 | Village Rd | F | 0.6 | 9.39 | | | 14x30PSC Gr+120x2 RE approach | 660 | | 57m | |
| 1089 | 389.685 | Village Rd | F | 1 | 4.3 | 40 | | 1x5.15x3.6 m RC box | | 37 | 195.68m & lowering 3.3m | |
| 1090 | 389.780 | Village Rd | F | 0.8 | 4.3 | 5 | | 1x5.15x3.6 m RC box | | 22 | 224.13m & lowering 3.5m | |
| 1091 | 391.280 | Village Rd | C | 0.9 | 9.39 | 0 | | 8x30PSC Gr+120x2 RE approach | 480 | | 75.27 m | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1092 | 391.330 | Village Rd | C | 0.45 | 9.39 | 75 | | 9x30PSC Gr+120x2 RE approach | 510 | | 62.74m | |
| 1093 | 392.150 | Village Rd | C | 1.9 | 9.39 | | | 9x30PSC Gr+120x2 RE approach | 510 | | 14.2m | |
| 1094 | 394.815 | Village Rd | C | 0.6 | 9.39 | 10 | | 7x30PSC Gr+120x2 RE approach | 450 | | 10.54m | |
| 1095 | 399.300 | Village Rd | F | 1.7 | 4.3 | 30 | | 1x5.15x3.6 m RC Box | | 27 | 239.6m & lowering 2.6m | |
| 1096 | 399.570 | Village Rd | F | 4.2 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 25 | 305.87m & 0.1m lg | |
| 1097 | 400.430 | Village Rd | C | 9.3 | 8.4 | 10 | | CT&CR 1x13.25x7.5 RC box | | | 191.81 | |
| 1098 | 402.212 | Village Rd | C | 6 | 8.4 | 0 | | 7x30PSC Gr. | 210 | | 14.61 | |
| 1099 | 403.585 | Village Rd | F | 9.5 | 5.8 | | | Below Viaduct | | | | |
| 1100 | 404.280 | Village Rd | F | 12.7 | 5.8 | 0 | | Below Viaduct | | | | |
| 1101 | 404.522 | Village Rd | F | 12.2 | 5.8 | 5 | | Below Viaduct | | | | |
| 1102 | 404.600 | MDR | F | 11.7 | 7.7 | 0 | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1103 | 404.745 | Village Rd | F | 13.7 | 7.7 | 0 | | Below Viaduct | | | | |
| 1104 | 405.250 | Village Rd | F | 3.1 | 4.3 | 20 | | 1x5.15x3.6 m RC box | | 23 | 59.87m & 1.2m lowg | |
| 1105 | 406.985 | Village Rd | F | 13.3 | 7.7 | 80 | | Below Viaduct | | | | |
| 1106 | 407.330 | Village Rd | F | 7.8 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 37 | 3.5 | |
| 1107 | 407.731 | NH | F | 7.6 | 7.7 | | | 2x18 m PSC GR | | 36 | | 0.1 |
| 1108 | 413.047 | Village Rd | F | 3.4 | 4.3 | 10 | | 1x5.15x3.6 m RC box | | 23 | | 0.9 |
| 1109 | 414.340 | SH | F | 0.7 | 9.39 | 45 | | 9x30PSC Gr+150x2 RE approach | 570 | | 6.8m | |
| 1110 | 415.982 | Village Rd | C | 6.9 | 9.39 | 0 | | 6x30PSC Gr+120x2 RE approach | 420 | | 13.3m | |
| 1111 | 417.660 | Village Rd | F | 2.6 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 35 | | 2.7 |
| 1112 | 417.735 | Kutcha Rd | F | 1.7 | 3 | 40 | | 1x4x2.5 m RC box | | 33 | | 1.3 |
| 1113 | 417.950 | ODR | F | 3.1 | 5.2 | 0 | | 1x5.15x4.5 m RC Box | | 20 | | 2.1 |
| 1114 | 418.085 | Kutcha Rd | F | 1.7 | 3 | 40 | | 1x4x2.5 m RC Box | | 33 | | 1.3 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1115 | 418.110 | Kutcha Rd | F | 1.2 | 3 | 10 | | 1x4x2.5 m RC Box | | 22 | | 1.8 |
| 1116 | 418.160 | Kutcha Rd | F | 0.95 | 3 | 40 | | 1x4x2.5 m RC Box | | 33 | | 2.05 |
| 1117 | 418.470 | Kutcha Rd | F | 3.8 | 4.3 | 5 | | 1x4x2.5 m RC Box | | 21 | | 0.5 |
| 1118 | 419.100 | ODR | C | 12.2 | 8.4 | 40 | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1119 | 420.740 | NH | F | 11.4 | 7.7 | | | Below Viaduct | | | | |
| 1120 | 420.830 | NH | F | 10.9 | 7.7 | | | Below Viaduct | | | | |
| 1121 | 422.100 | Village Rd | F | 18 | 5.8 | 15 | | Below Viaduct | | | | |
| 1122 | 422.450 | Village Rd | F | 11.3 | 5.8 | 0 | | Below Viaduct | | | | |
| 1123 | 422.540 | Village Rd | F | 8.8 | 5.8 | 45 | | Below Viaduct | | | | |
| 1124 | 422.800 | Kutcha Rd | F | 0.3 | 3 | 45 | | 1x4x2.5 m RC box | | 37 | | 2.7 |
| 1125 | 422.822 | Village Rd | F | 0.7 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 37 | | 3.6 |
| 1126 | 422.930 | Kutcha Rd | F | 2.6 | 3 | 45 | | 1x4x2.5 m RC box | | 35 | | 0.4 |

| S.No | Chainage | Type of Road | Filling/Cutting&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1127 | 422.970 | Village Rd | F | 3.4 | 4.3 | 30 | | 1x5.15x3.6 m RC box | | 30 | | 0.9 |
| 1128 | 423.030 | Village Rd | F | 5.7 | 4.3 | 45 | | 1x5.15x3.6 m RC box | | 37 | 1.4 | |
| 1129 | 423.470 | ODR | F | 2.4 | 5.2 | 45 | | 1x5.15x4.5 m RC box | | 38 | | 2.8 |
| 1130 | 423.622 | Village Rd | F | 4.2 | 4.3 | 40 | | 1x5.15x3.6 m RC Box | | 33 | | 0.1 |
| 1131 | 423.687 | Village Rd | F | 4.4 | 4.3 | 45 | | 1x5.15x3.6 m RC Box | | 38 | 0.1 | |
| 1132 | 423.735 | Village Rd | F | 4.4 | 4.3 | 40 | | 1x5.15x3.6 m RC Box | | 35 | 0.1 | |
| 1133 | 424.095 | Village Rd | F | 3.8 | 9.39 | 45 | | 14x30PSC Gr+120x2 RE approach | 660 | | 53.02m | |
| 1134 | 424.160 | ODR | F | 4.5 | 9.39 | 45 | | 14x30PSC Gr+120x2 RE approach | 660 | | 43.2 m | |
| 1135 | 424.200 | ODR | F | 4.5 | 9.39 | 45 | | 14x30PSC Gr+120x2 RE approach | 660 | | 34.15m | |
| 1136 | 424.700 | MDR | F | 7.05 | 9.39 | 40 | | 20x30PSC Gr+120x2 RE approach | 840 | | 26.3m | |
| 1137 | 425.005 | Village Rd | F | 13.3 | 5.8 | 0 | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1138 | 425.155 | NH | F | 14 | 7.7 | 10 | | Below Viaduct | | | | |
| 1139 | 426.100 | Village Rd | F | 10 | 5.8 | 75 | | Below Viaduct | | | | |
| 1140 | 426.275 | Village Rd | C | 0.2 | 9.39 | 35 | | 10x30PSC Gr+120x2 RE approach | 540 | | 118.93m | |
| 1141 | 426.645 | Village Rd | C | 7.1 | 8.4 | 5 | | Mini ROB 1x12x7.5 RC box | 10 | | 220.05m | |
| 1142 | 427.023 | ODR | F | 6.2 | 5.2 | 0 | | 1x5.15x4.5 m RC Box | | 20 | 78m & 1m cushion | |
| 1143 | 427.585 | Village Rd | C | 1.4 | 9.39 | 10 | | 5x30PSC Gr+120x2 RE approach | 390 | | 39.47m | |
| 1144 | 428.080 | Kutcha Rd | F | 10.3 | 4.7 | 0 | | Below Viaduct | | | | |
| 1145 | 428.750 | Village Rd | C | 6.5 | 9.39 | 30 | | 6x30m PSC Gr + 2x240 m RE Approach | 15 | | 36.32m | |
| 1146 | 429.795 | Village Rd | F | 2.8 | 9.39 | 40 | | 12x30m PSC Gr + 2x120m RE Approach | 600 | 25 | 52.58 | |
| 1147 | 431.638 | Village Rd | F | 6 | 9.39 | 0 | | 15x30m PSC Gr + 2x120m RE Approach | 690 | 25 | 28.05m | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1148 | 434.170 | Village Rd | F | 0.7 | 9.39 | 10 | | 8x30PSC Gr+120x2 RE approach | 480 | | 24.36m | |
| 1149 | 434.950 | NH | F | 5.2 | 7.7 | 45 | | Below Viaduct | | | | 2.7 m |
| 1150 | 436.630 | Kutcha Rd | F | 1.2 | 3 | 5 | | 1x4x2.5m RC box | | 21 | (Dist121.3m) | 1.8 |
| 1151 | 436.823 | Kutcha Rd | C | 0.4 | 8.4 | 45 | | Mini ROB 1x12x7.5 RC box | 10 | | 265.92m | |
| 1152 | 438.200 | NH | F | 6.4 | 7.7 | 45 | | 2x18m PSC Gr | | 36 | (Not crossing existing Rly) | 1.3 |
| 1153 | 441.325 | MDR | F | 11 | 7.7 | | | Below Viaduct | | | | |
| 1154 | 441.895 | MDR | F | 13 | 7.7 | | | Below Viaduct | | | | |
| 1155 | 442.073 | Kutcha Rd | F | 13 | 3 | | | Below Viaduct | | | | |
| 1156 | 442.635 | ODR | F | 12 | 6.7 | | | Below Viaduct | | | | |
| 1157 | 442.885 | MDR | F | 1.9 | 6.7 | 0 | 7 | 1x10x5.5 m RC box | | 170 | | 4.8 |
| 1158 | 443.135 | ODR | C | 6.5 | 8.4 | 0 | 5 | Mini ROB 1x12x7.5 RC box | 6 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1159 | 443.285 | Village Rd | C | 7.3 | 8.4 | | 5 | Mini ROB 1x12x7.5 RC box | 6 | | | |
| 1160 | 443.385 | ODR | C | 6.3 | 8.4 | 70 | 6.5 | Mini ROB 1x12x7.5 RC box | 54 | | | |
| 1161 | 443.585 | ODR | F | 3 | 5.2 | 10 | 5 | 1x5.15x4.5 m RC Box | | 21 | | 2.2 |
| 1162 | 444.347 | ODR/ LC | | | 9.39 | 10 | 8 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1163 | 445.355 | ODR | F | 6.7 | 6.7 | | | Below Viaduct | | | | |
| 1164 | 445.489 | MDR | F | 4.7 | 7.7 | | | Below Viaduct | | | | |
| 1165 | 446.435 | MDR | C | 1.2 | 6.7 | | 9 | 1x10x5.5 m RC box | | 75 | | 7.9 |
| 1166 | 448.02 | ODR/ LC | C | 3.8 | 9.39 | 0 | 6 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1167 | 450.006 | ODR/ LC | | 0 | 9.39 | 20 | 5 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1168 | 451.162 | MDR | C | 9.6 | 8.4 | 0 | 6.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1169 | 452.061 | Village Rd | F | 3 | 4.3 | 10 | 3 | 1x5.15x3.6 m RC Box | | 22 | | 1.3 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1170 | 452.871 | MDR/ LC | F | 4 | 9.39 | 0 | 5.5 | 14x30PSC Gr+150x2 RE approach | 730 | | | |
| 1171 | 454.063 | Adj.. ROB | | | | 45 | 8.5 | 1x11.5x7.5 RC Box | | | | |
| 1172 | 457.25 | MDR/ LC | F | 0.1 | 9.39 | 10 | 5.5 | 8x30PSC Gr+150x2 RE approach | 535 | | | |
| 1173 | 459.596 | MDR/ LC | C | 0.9 | 9.39 | 10 | 5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1174 | 460.685 | Village Rd | F | 0.1 | 4.3 | 10 | 4 | 1x5.15x3.6 m RC Box | | 25 | Subway is proposed for 35m | |
| 1175 | 461.131 | MDR/ LC | C | 0.1 | 9.39 | 5 | 5.5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1176 | 462.151 | Village Rd/LC | F | 0.5 | 9.39 | 0 | 5 | 7x30PSC Gr+120x2 RE approach | 456 | | | |
| 1177 | 462.835 | MDR/ LC | C | 0.1 | 9.39 | 45 | 5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1178 | 465.918 | Village Rd/LC | F | 1.3 | 9.39 | 0 | 5 | 8x30PSC Gr+120x2 RE approach | 488 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1179 | 466.319 | Village Rd | F | 0.3 | 8.4 | 10 | 3 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 1180 | 466.635 | Village Rd | F | 1.1 | 9.39 | 10 | 5 | 8x30PSC Gr+120x2 RE approach | 478 | | | |
| 1181 | 467.435 | Village Rd | F | 2.6 | 5.2 | 45 | 5 | 1x5.15x4.5 m RC Box | | 37 | | 2.6 |
| 1182 | 467.606 | MDR | C | 3.8 | 8.4 | 45 | 13 | Mini ROB 1x12x7.5 RC box | 30 | | | |
| 1183 | 469.835 | Village Rd | F | 5.3 | 5.2 | 10 | 4 | 1x5.15x4.5 m RC Box | | 23 | 0.1 | |
| 1184 | 470.715 | Village Rd | F | 5.5 | 5.2 | 10 | 4 | 1x5.15x4.5 m RC Box | | 23 | 0.3 | |
| 1185 | 471.112 | Kutcha Rd | F | 0.3 | 3 | 45 | 3 | 1x4x2.5 mRC Box | | 37 | | 2.7 |
| 1186 | 471.479 | Village Rd | F | 3.2 | 5.2 | 45 | 3.5 | 1x5.15x4.5 m RC Box | | 37 | | 2 |
| 1187 | 472.23 | Kutcha Rd | F | 0 | 3 | 25 | 2 | 1x4x2.5 mRC Box | | 30 | | 3 |
| 1188 | 473.315 | MDR/ LC | F | 1.5 | 9.39 | 0 | 5.5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1189 | 477.335 | Kutcha Rd | C | 1 | 8.4 | 45 | 3.5 | Mini ROB 1x12x7.5 RC box | 20 | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1190 | 477.804 | Village Rd | C | 0.4 | 8.4 | 45 | 3 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 1191 | 478.157 | Village Rd | F | 0.9 | 3 | 10 | 4 | 1x4x2.5 mRC Box | | 23 | | 2.1 |
| 1192 | 478.942 | Adj.. ROB | F | 2.3 | 8.9 | 0 | 7.5 | 1x11.5x7.5 RC Box | | | | |
| 1193 | 480.187 | Village Rd | F | 2.2 | 4.3 | 20 | 2.5 | 1x5.15x3.6 m RC Box | | 25 | | 2.1 |
| 1194 | 481.181 | Village Rd | F | 3.6 | 5.8 | 70 | 3.5 | 1x6x 5 m RC Box | | | | 2.2 |
| 1195 | 481.379 | Kutcha Rd | F | 2.2 | 5.8 | 30 | 6 | 1x6x5 m RC Box | | 25 | | 3.6 |
| 1196 | 482.253 | MDR/ LC | C | 0.1 | 9.39 | 20 | 5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1197 | 483.462 | MDR | F | | 9.39 | 70 | 5.5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1198 | 486.203 | MDR/ LC | C | 0.1 | 9.39 | 0 | 5.5 | 8x30PSC Gr+150x2 RE approach | 530 | | | |
| 1199 | 490.847 | Adj.. ROB | C | 4.6 | 8.9 | 0 | 8.5 | 1x11.5x7.5 RC Box | | | | |
| 1200 | 492.335 | Adj.. ROB | F | 0.71 | 8.9 | 0 | 11 | 1x11.5x7.5 RC Box | | | | |
| 1201 | 494.66 | Kutcha Rd | F | 2.3 | 3 | 0 | 5.5 | 1x5.5x RC Box | | 20 | | 0.7 |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1202 | 495.104 | Kutcha Rd | F | 2.6 | 3 | 5 | 2 | 1x4x2.5 mRC Box | | 20 | | 0.4 |
| 1203 | 495.961 | Kutcha Rd/LC | F | 3.5 | 9.39 | 30 | 7.5 | 9x30PSC Gr+120x2 RE approach | 576 | | | |
| 1204 | 495.979 | NH/ LC | F | 3.2 | 9.39 | 15 | 7.5 | 13x30PSC Gr+150x2 RE approach | 690 | | | |
| 1205 | 496.704 | ODR/ LC | C | 0.4 | 9.39 | 45 | 8 | 7x30PSC Gr+150x2 RE approach | 436 | | | |
| 1206 | 500.835 | Adj.ROB | F | 1.4 | | | | 1x11.5x7.5 m RC box | | | | |
| 1207 | 500.907 | NH | F | 0.2 | 9.39 | 45 | 11 | 12x30PSC Gr+240x2 RE approach | 827 | | | |
| 1208 | 505.937 | ODR/ LC | F | 0.4 | 9.39 | 0 | 7 | 7x30PSC Gr+120x2 RE approach | 453 | | | |
| 1209 | 507.577 | ODR/ LC | C | 0.6 | 9.39 | 0 | 4.5 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1210 | 507.628 | Adj.. ROB | F | 0.2 | | | | 1x11.5x7.5 RC Box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1211 | 508.268 | ODR/ LC | C | 0.7 | 9.39 | 0 | 6 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1212 | 513.185 | Village Rd | F | 1.5 | 4.3 | 80 | 3 | 1x5.15x3.6 m RC Box | | 50 | | 2.8 |
| 1213 | 513.504 | Village Rd/LC | C | 1.5 | 9.39 | 0 | 7.5 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1214 | 516.59 | NH | C | 0.8 | 9.39 | 40 | 12 | 11x30PSC Gr+150x2 RE approach | 811 | | | |
| 1215 | 517.261 | Kutcha Rd/LC | C | 2.3 | 9.39 | 0 | 5.5 | 7x30PSC Gr+120x2 RE approach | 436 | | | |
| 1216 | 517.367 | Village Rd | C | 2.8 | 8.4 | 10 | 7 | Mini ROB 1x12x7.5 RC box | 8.4 | | | |
| 1217 | 517.735 | Kutcha Rd | C | 4.2 | 8.4 | 10 | 4 | Mini ROB 1x12x7.5 RC box | 7.3 | | | |
| 1218 | 517.796 | MDR | C | 6.7 | 8.4 | 0 | 7.5 | Mini ROB 1x12x7.5 RC box | 12 | | | |
| 1219 | 518.07 | Village Rd | C | 11 | 8.4 | 0 | 5.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1220 | 518.575 | Kutcha Rd | F | 9 | 4.7 | | | Below Viaduct | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1221 | 518.761 | Kutcha Rd | F | 9.1 | 4.7 | | | Below Viaduct | | | | |
| 1222 | 518.867 | Kutcha Rd | F | 9.7 | 4.7 | | | Below Viaduct | | | | |
| 1223 | 518.951 | Kutcha Rd | F | 8.5 | 4.7 | | | Below Viaduct | | | | |
| 1224 | 519.18 | ODR | F | 3.2 | 5.2 | | | 1x5.15x4.5 m RC Box | | 20 | | 2 |
| 1225 | 519.57 | Village Rd | F | 3.2 | 4.3 | 0 | 3.5 | 1x5.15x3.6 m RC Box | | 20 | | 1.1 |
| 1226 | 519.919 | Kutcha Rd | F | 6 | 3 | 0 | 2.5 | 1x4x2.5 mRC Box | | 20 | 3 | |
| 1227 | 520.056 | ODR | F | 2.4 | 5.2 | 25 | 7.5 | 1x5.15x4.5 m RC Box | | 25 | | 2.8 |
| 1228 | 520.135 | Village Rd | F | 1 | 4.3 | 70 | 3 | 1x5.15x3.6 m RC Box | | 75 | | |
| 1229 | 521.367 | Village Rd | C | 0.6 | 8.4 | 45 | 4 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 1230 | 521.495 | Kutcha Rd | C | 4 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 1231 | 521.574 | Kutcha Rd | C | 6.3 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 1232 | 521.704 | Kutcha Rd | C | 9.6 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1233 | 521.835 | NH | C | 8.3 | 8.4 | | 7.5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1234 | 522.222 | Kutcha Rd | C | 6.5 | 8.4 | | | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 1235 | 522.319 | Village Rd | C | 8.4 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1236 | 522.34 | Village Rd | C | 8.8 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1237 | 522.435 | Kutcha Rd | C | 9.5 | 8.4 | | | CT&CR 1x13.25x7.5 RC box | | | | |
| 1238 | 522.607 | ODR | C | 8.3 | 8.4 | 45 | 7 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1239 | 522.994 | Village Rd | C | 3 | 8.4 | 45 | 4.5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 1240 | 523.073 | Kutcha Rd | C | 1.3 | 8.4 | 45 | 3.5 | Mini ROB 1x12x7.5 RC box | 20 | | | |
| 1241 | 523.14 | Village Rd | F | 0.1 | 8.4 | 45 | 3.5 | Mini ROB 1x12x7.5 RC box | 22 | | | |
| 1242 | 523.435 | Village Rd | C | 8.5 | 8.4 | 45 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1243 | 524.182 | Village Rd | C | 11 | 8.4 | 0 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1244 | 524.391 | Kutcha Rd | C | 7.5 | 8.4 | 40 | 3 | Mini ROB 1x12x7.5 RC box | 18 | | | |
| 1245 | 524.515 | Village Rd | F | 1.1 | 4.3 | 45 | | 1x5.15x3.6 m RC Box | | 37 | | 3.2 |
| 1246 | 524.577 | Village Rd | F | 6.5 | 4.3 | 40 | | 1x5.15x3.6 m RC Box | | 33 | 2.2 | |
| 1247 | 524.977 | Village Rd | F | 7.6 | 5.8 | 25 | 4 | Below Viaduct | | 27 | | |
| 1248 | 525.112 | Kutcha Rd | F | 5 | 3 | 45 | 4. | 1x4x2.5 mRC Box | | 37 | 2 | |
| 1249 | 525.189 | Kutcha Rd | F | 3 | 3 | 45 | 3.5 | 1x4x2.5 mRC Box | | 35 | 0 | |
| 1250 | 525.448 | Kutcha Rd | C | 14 | 8.4 | 20 | 5 | CT&CR 1x13.25x7.5 RC box | | | | |
| 1251 | 525.924 | Kutcha Rd | F | 5.3 | 3 | 70 | | 1x4x2.5 mRC Box | | 72 | 1.3 | |
| 1252 | 526.156 | Kutcha Rd | F | 4 | 3 | 45 | 6 | 1x4x2.5 mRC Box | | 33 | 1 | |
| 1253 | 526.329 | Village Rd | F | 1.9 | 4.3 | 0 | | 1x5.15x3.6 m RC box | | 20 | | 2.4 |
| 1254 | 526.548 | Kutcha Rd | F | 4.9 | 3 | | | 1x4x2.5 mRC Box | | 20 | 1.9 | |

| S.No | Chainage | Type of Road | Filling/Cutting/Cut&Cover | Vertical Clearance (m) | | Skew (deg) | Exg. ROW(m) | Dimension of Structure(m) | Length of Bridge structure (m) | | Remarks (Cushion/lowering if any) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Available | Required | | | | ROB | RUB | Cushion | Lowering |
| 1255 | 527.521 | Village Rd | F | 7 | 6.7 | 5 | 4.5 | 1x10x5.5m RC Box | | 23 | 0.3 | |
| 1256 | 528.57 | Kutcha Rd | C | 4.2 | 8.4 | 10 | 4.4 | Mini ROB 1x12x7.5 RC box | 4.8 | | | |
| 1257 | 528.825 | Village Rd | C | 6 | 8.4 | 5 | 4 | CT&CR 1x13.25x7.5 RC box | | | | |

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